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Ghanadiof et al.

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(45) **Date of Patent: Jul. 9, 2024**

(54) **SYSTEM AND METHOD FOR INSPECTING AND MAINTAINING THE EXTERIOR ELEVATED ELEMENTS OF BUILDING STRUCTURES**

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(Continued)

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G06T 7/00 (2017.01)
G06T 7/90 (2017.01)
G06V 20/10 (2022.01)

(52) **U.S. Cl.**
CPC **G06T 7/0008** (2013.01); **G06T 7/90** (2017.01); **G06V 20/176** (2022.01);
(Continued)

(58) **Field of Classification Search**
CPC **G06T 7/0008**; **G06T 7/90**; **G06T 2207/10004**; **G06T 2207/10016**;
(Continued)

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Portions of prosecution history of U.S. Appl. No. 18/075,927, filed Jan. 31, 2024, Ghanadiof, Omidreza, et al.

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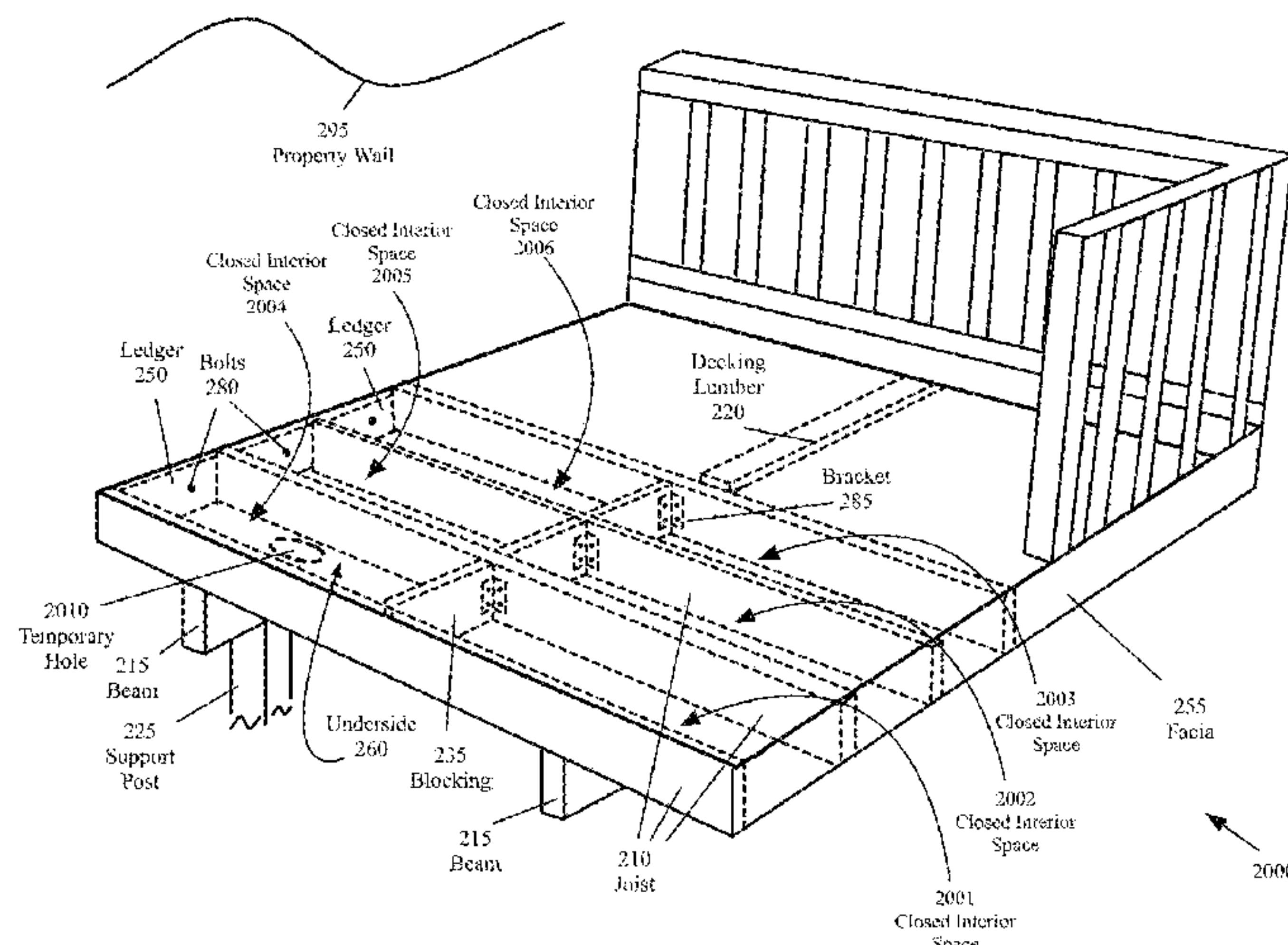
Primary Examiner — Manav Seth

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(57) **ABSTRACT**

A method of inspecting a balcony is provided. The method, from the outside of the balcony, detects locations of two wooden joists in the interior of the balcony, where there is no access to pass a camera from the outside of the balcony into the interior space between the two joists. The method drills a hole into the interior space of the balcony and passes a camera through the hole into the interior space of the balcony. The method captures one or more images by the camera from the wooden surfaces in the interior space of balcony. The method analyzes the images to determine the existence of wood rot in the interior space of the balcony. The method removes the camera from the interior space of the balcony. The method seals the hole.

22 Claims, 27 Drawing Sheets



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- (52) **U.S. Cl.**
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- (58) **Field of Classification Search**
CPC G06T 2207/10132; G06T 2207/30161; G06V 20/176
See application file for complete search history.

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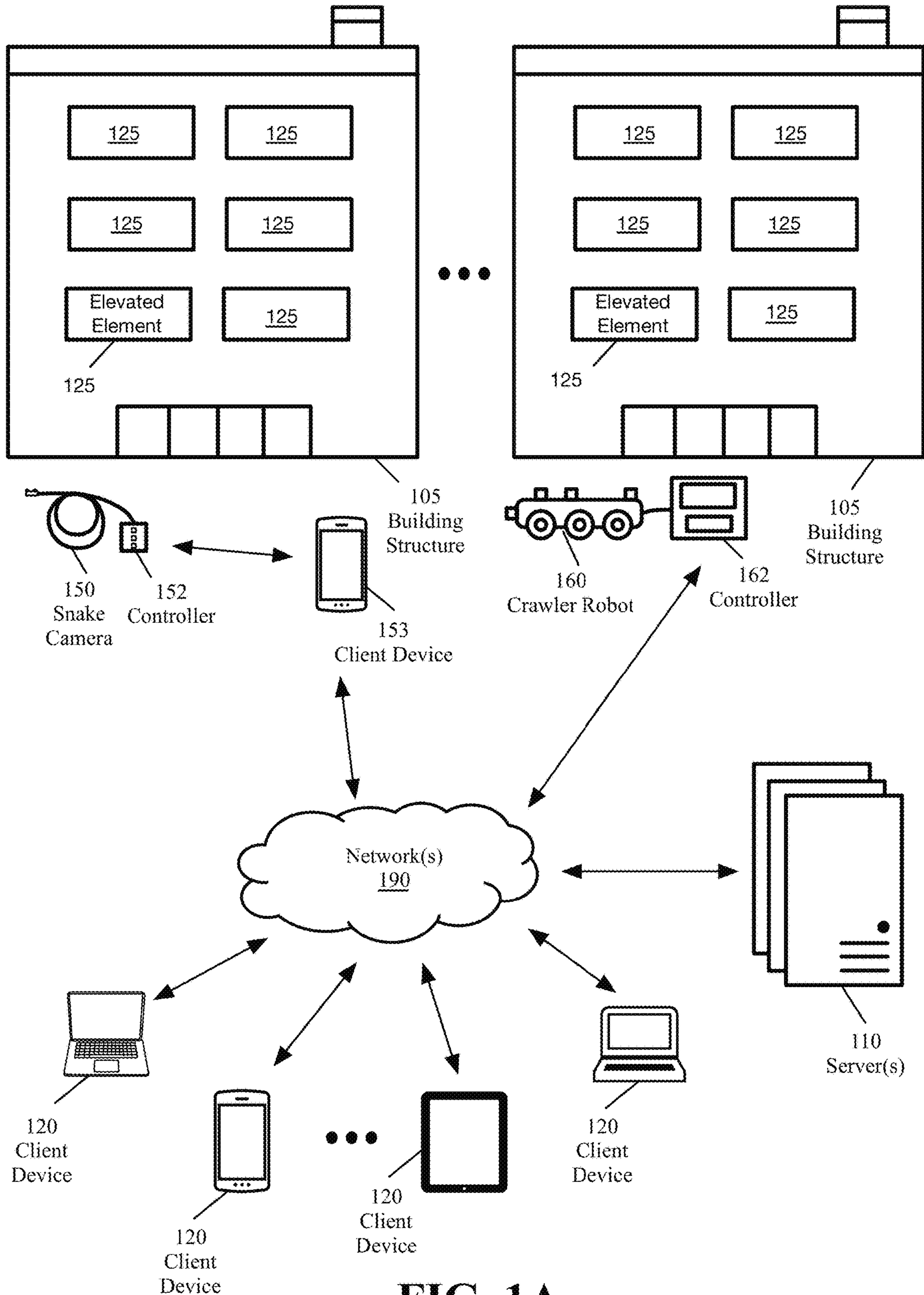


FIG. 1A

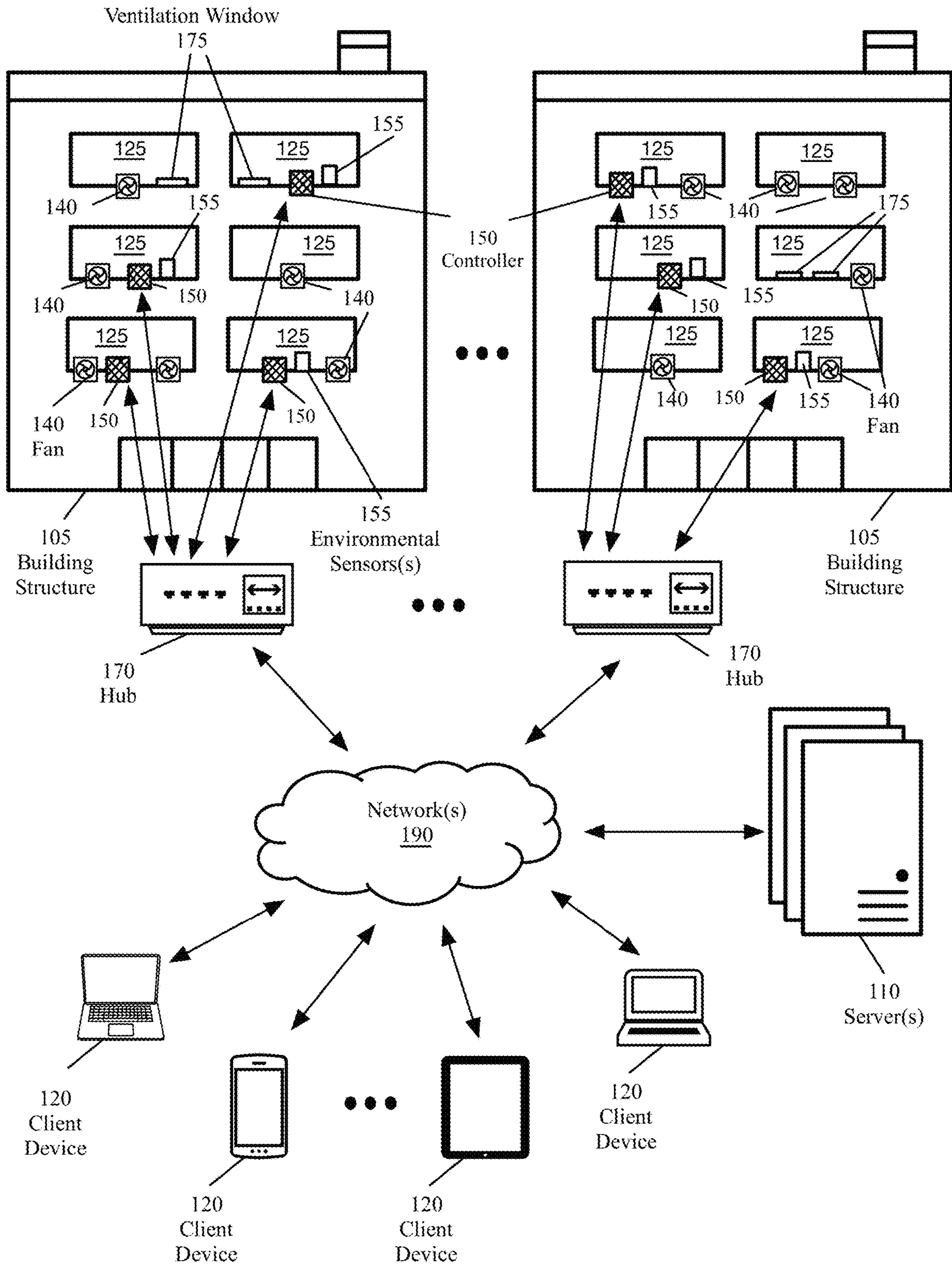


FIG. 1B

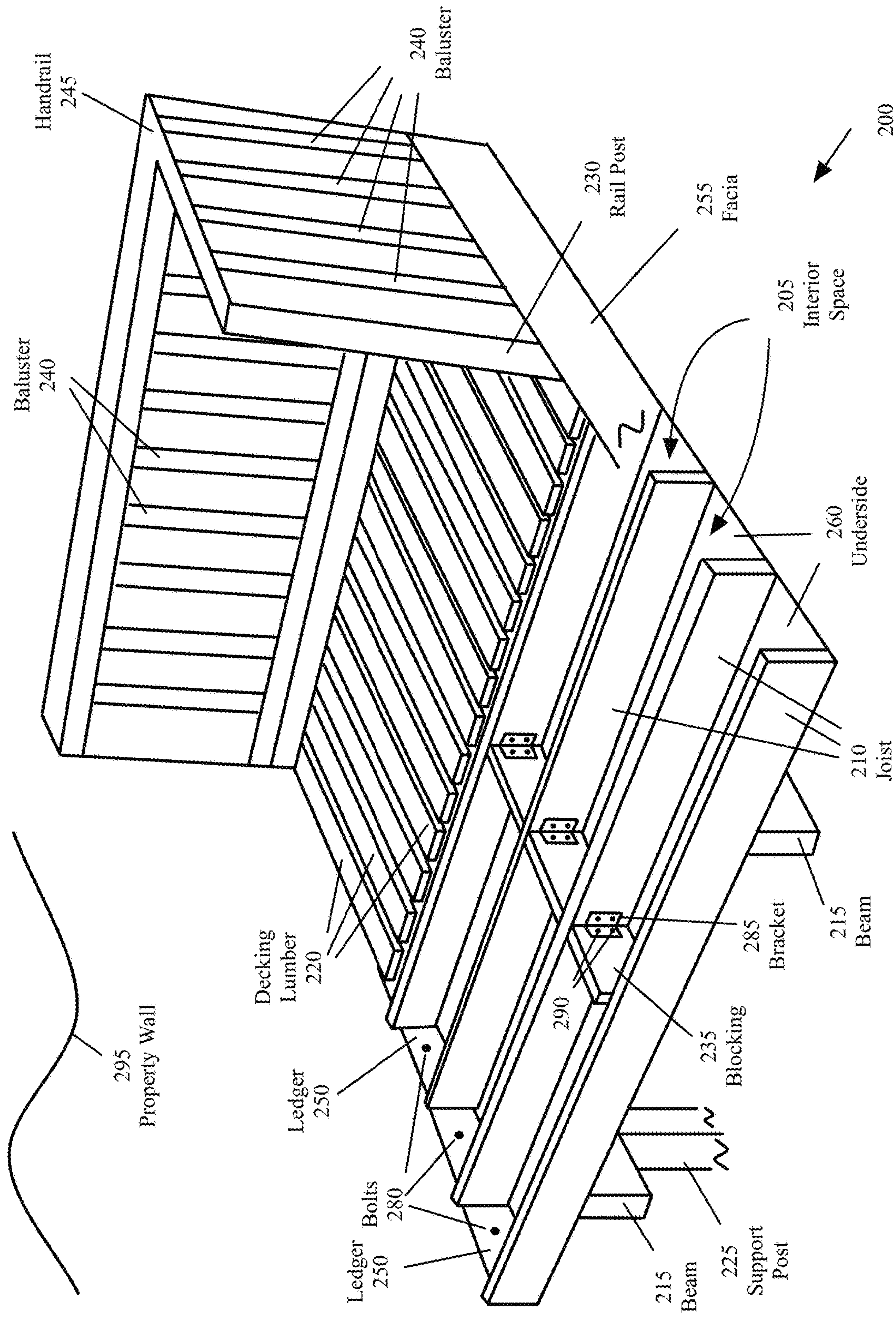


FIG. 2
Prior Art

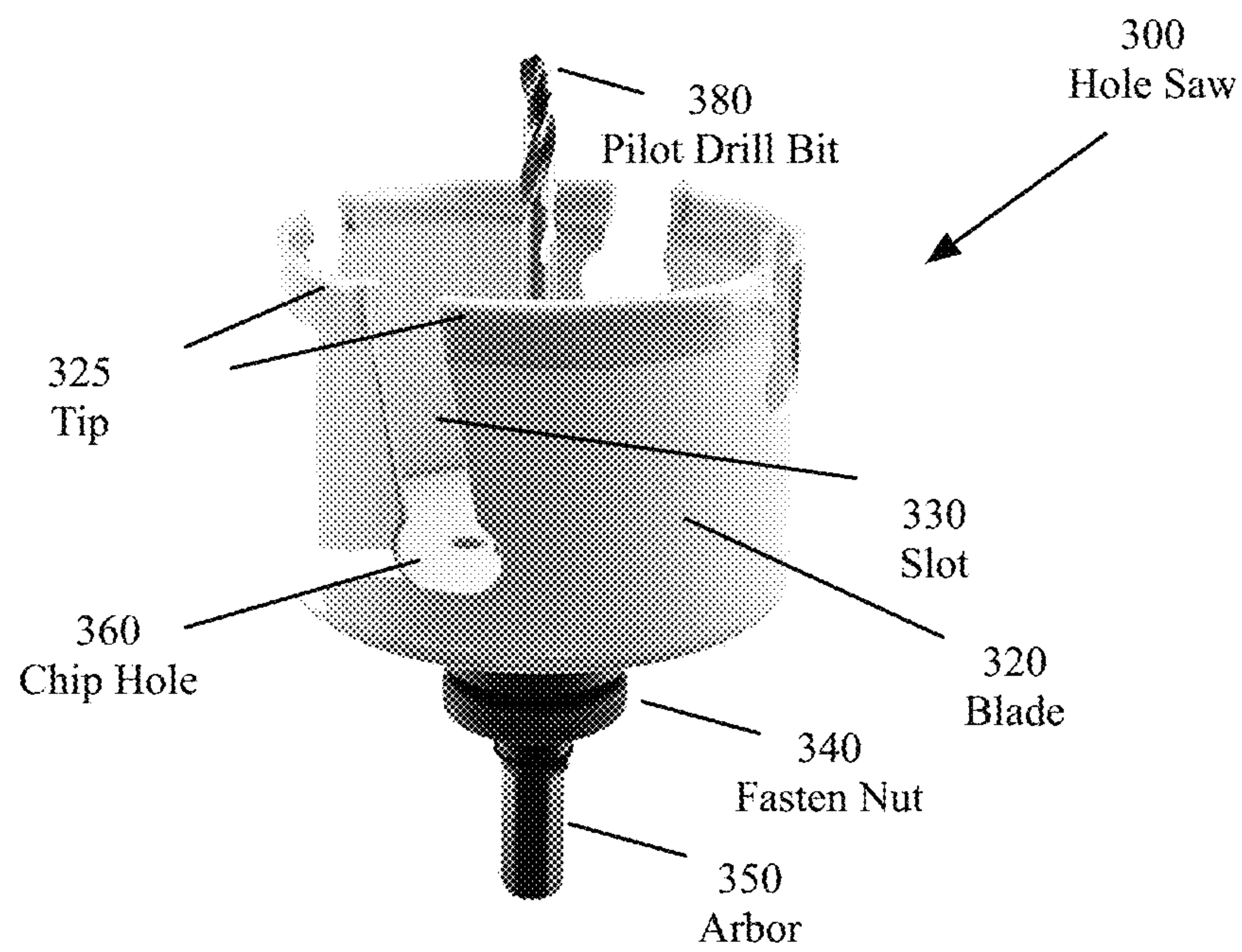


FIG. 3
Prior Art

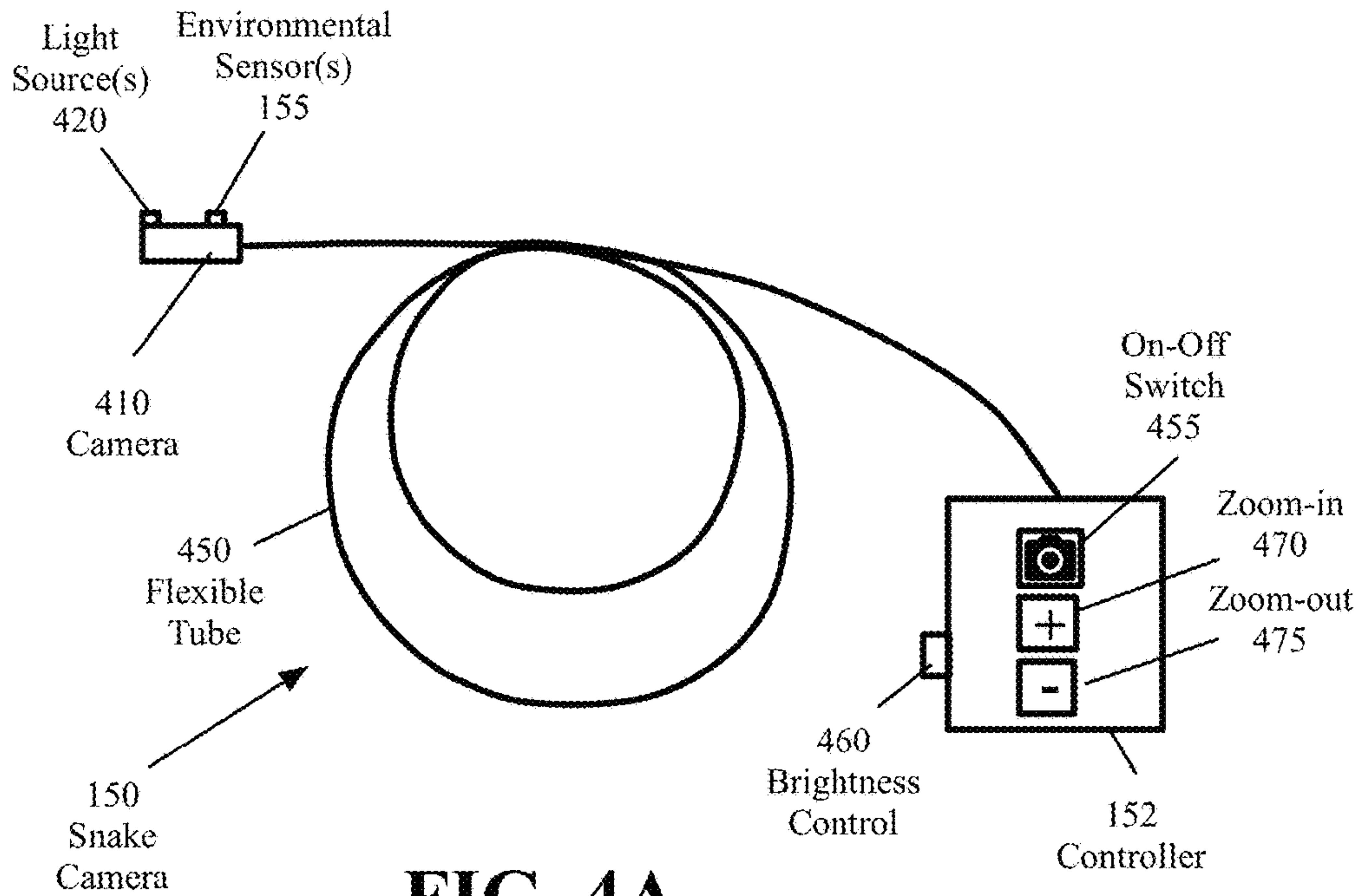


FIG. 4A

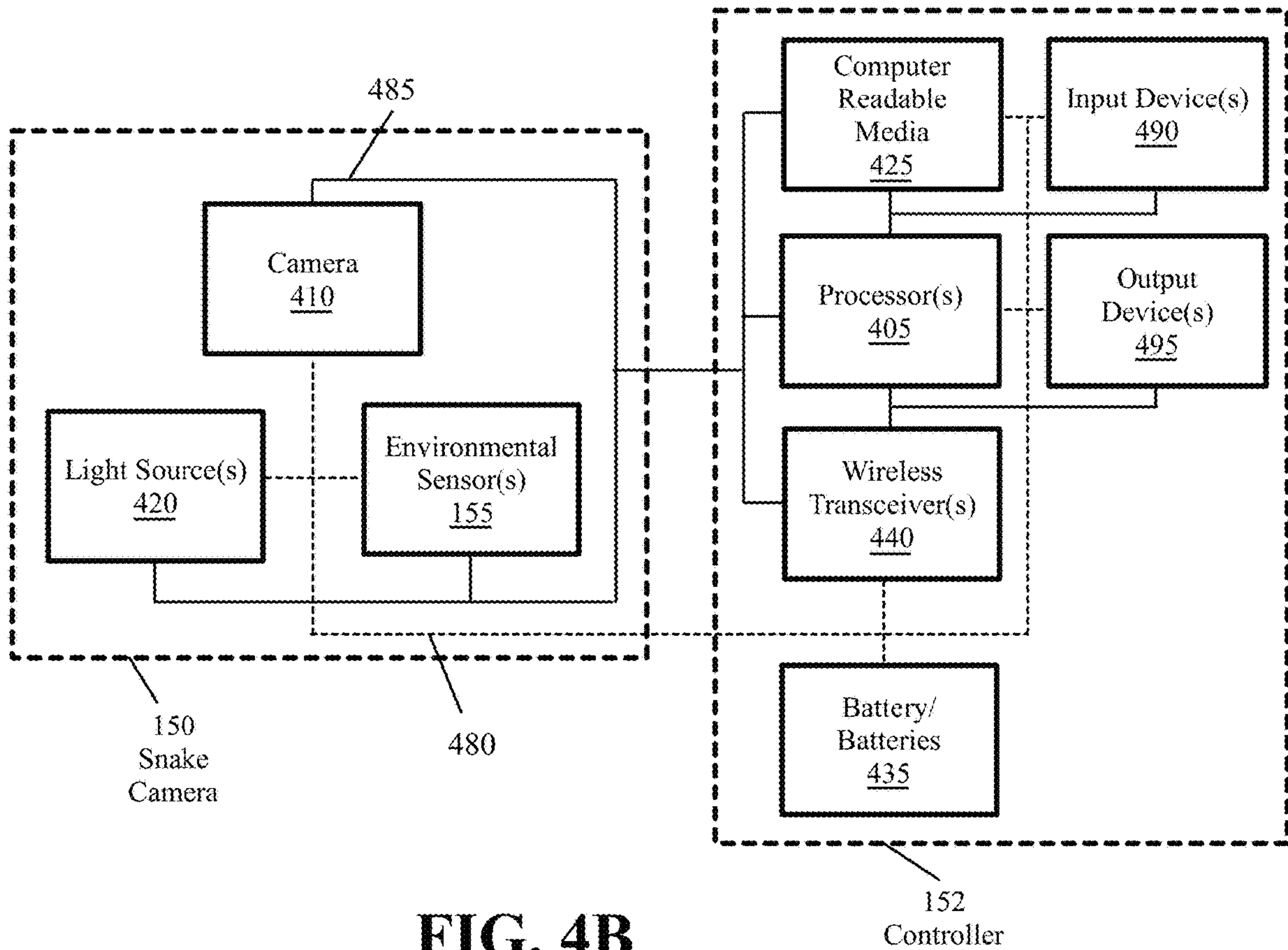


FIG. 4B

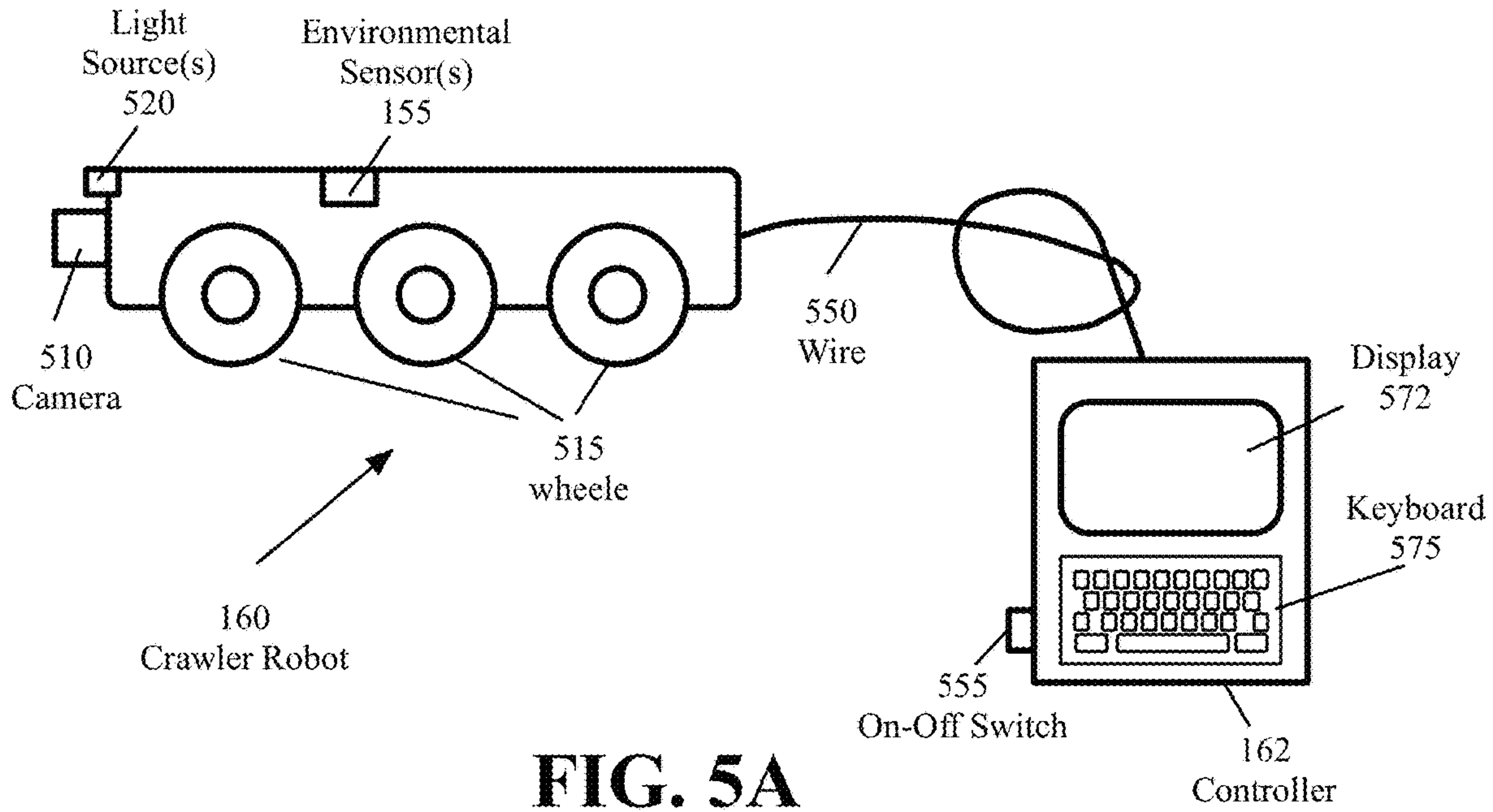


FIG. 5A

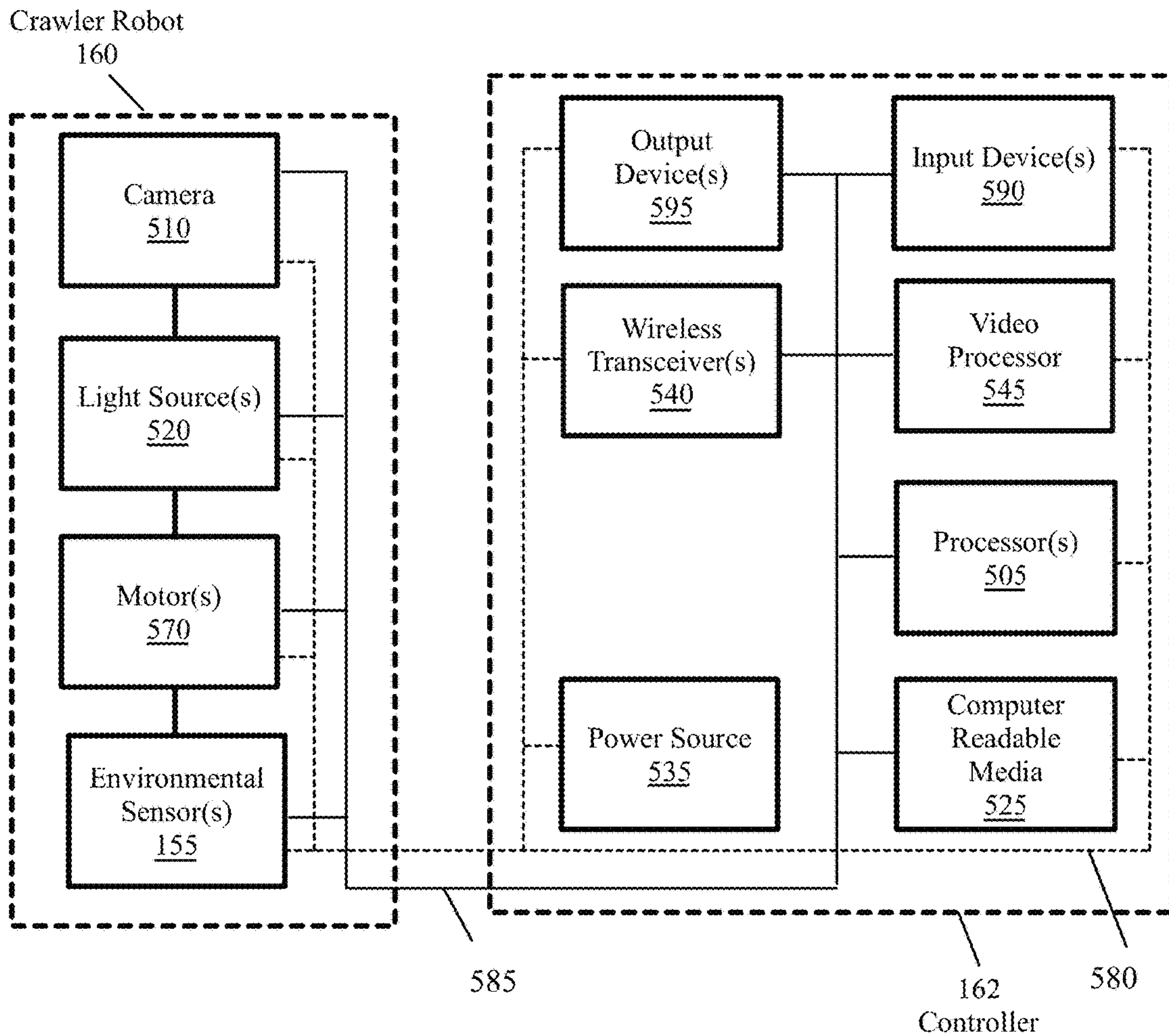


FIG. 5B

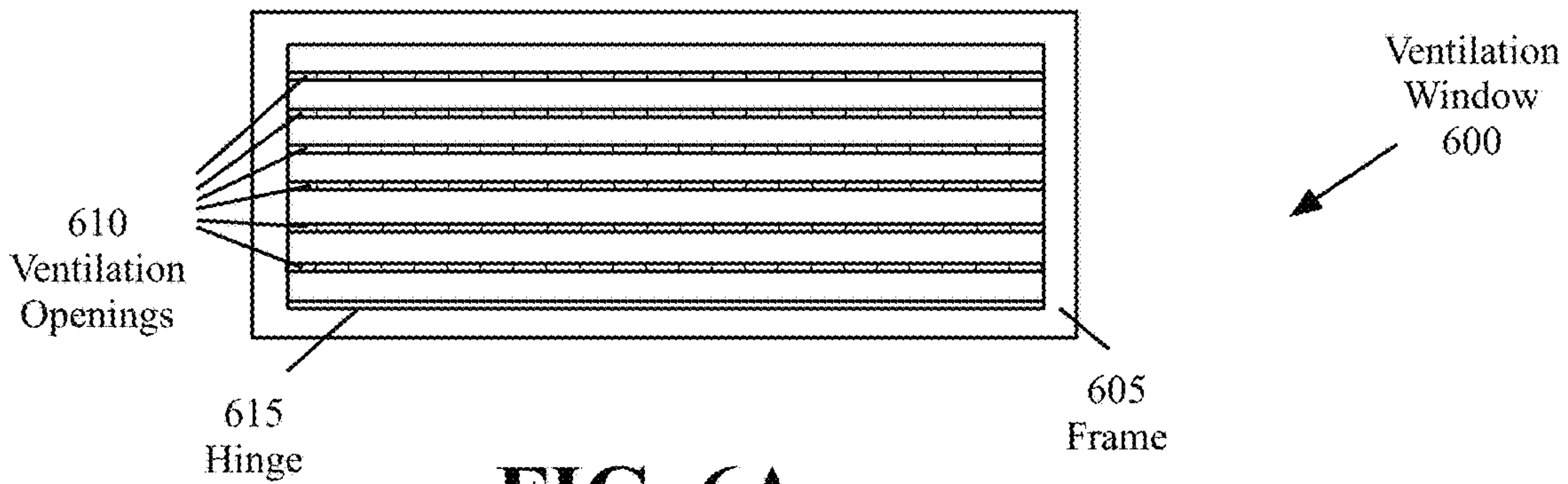


FIG. 6A

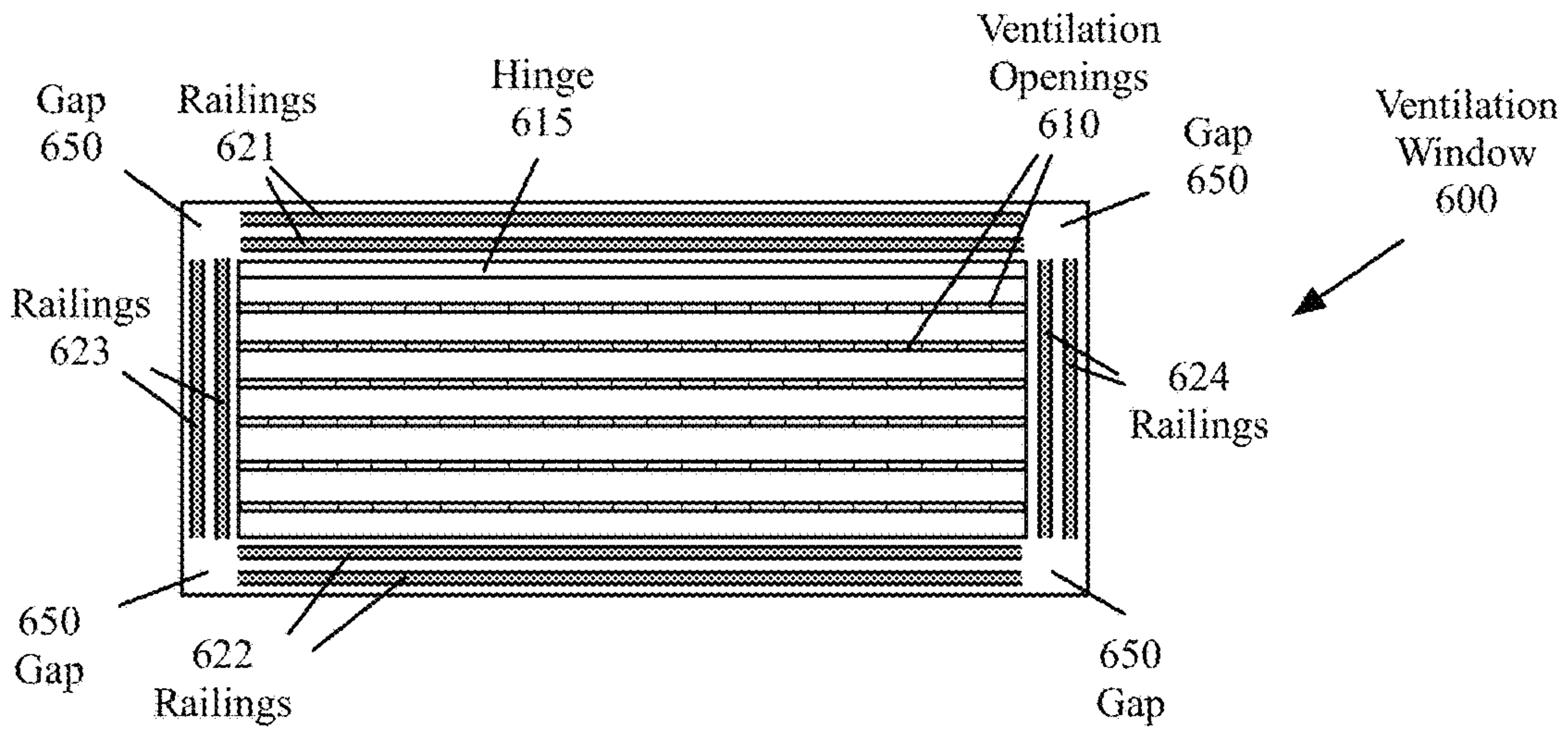


FIG. 6B

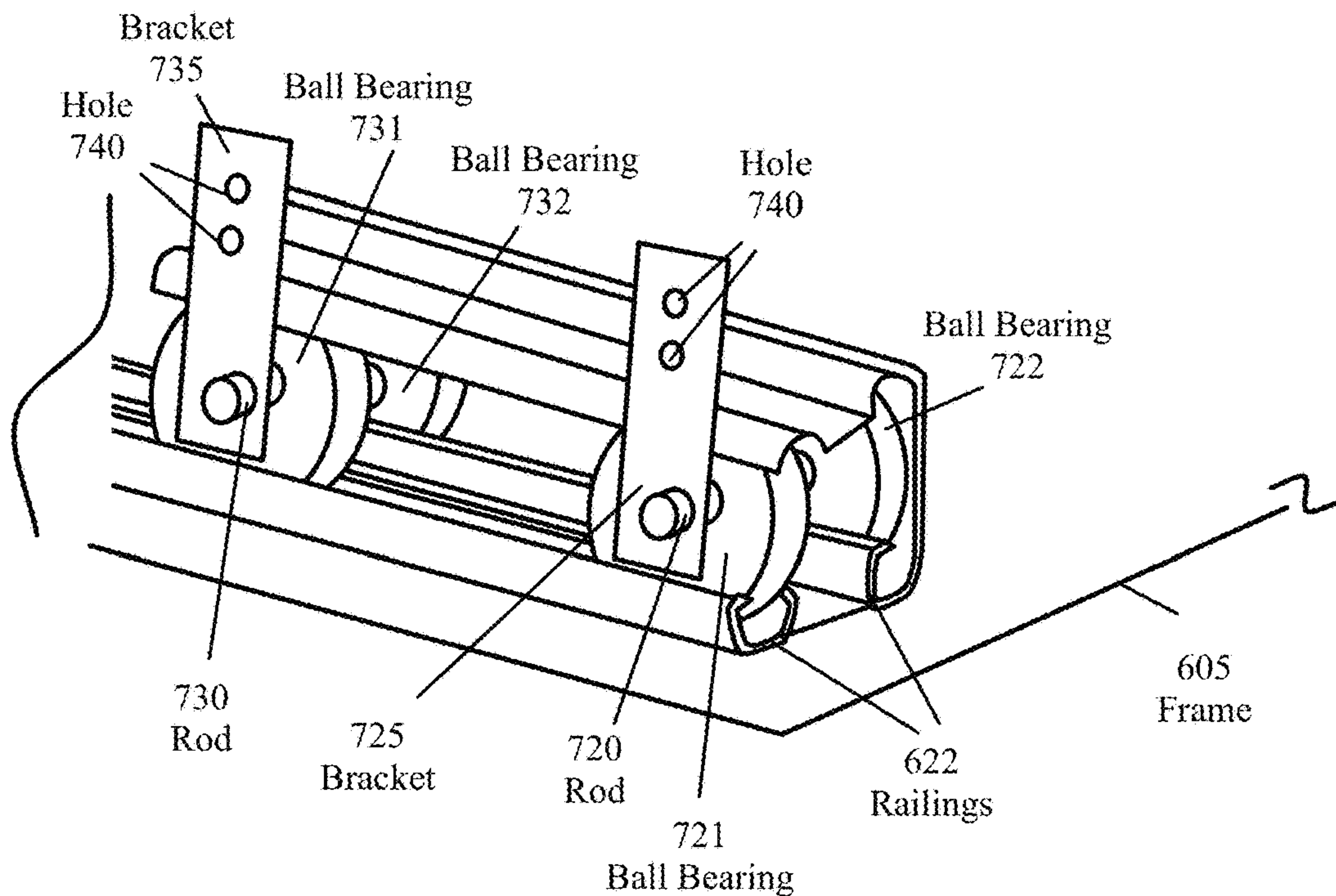


FIG. 7

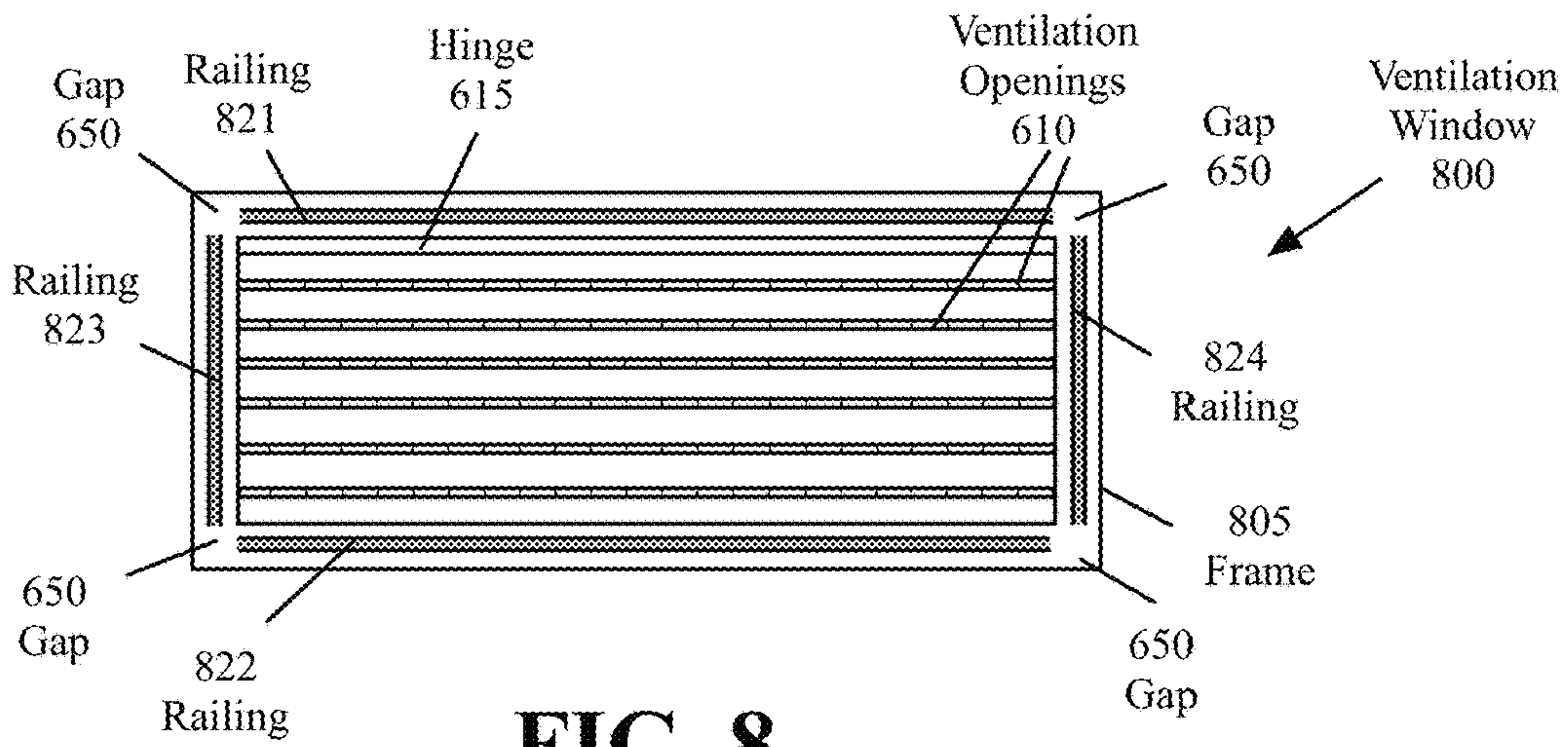


FIG. 8

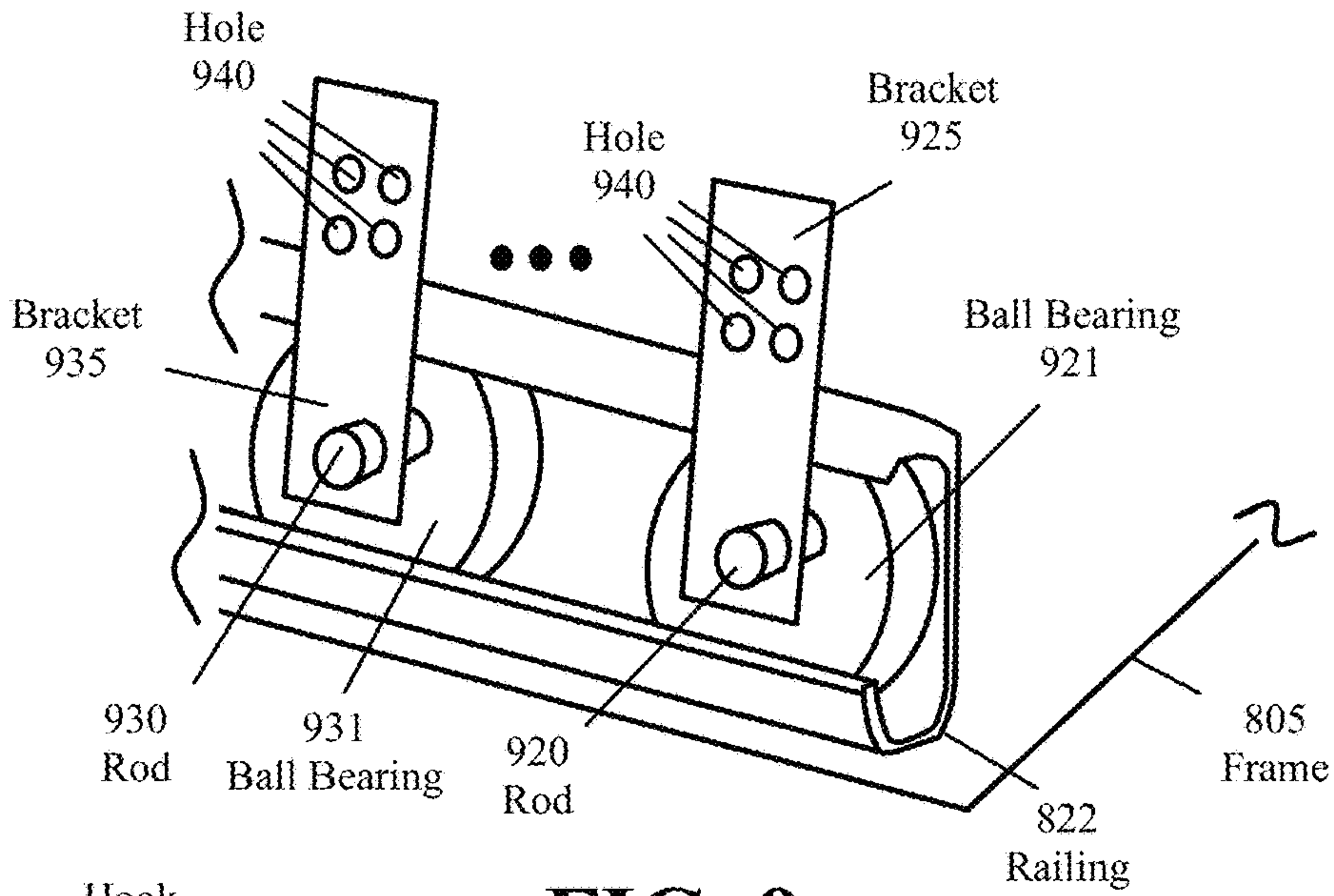


FIG. 9

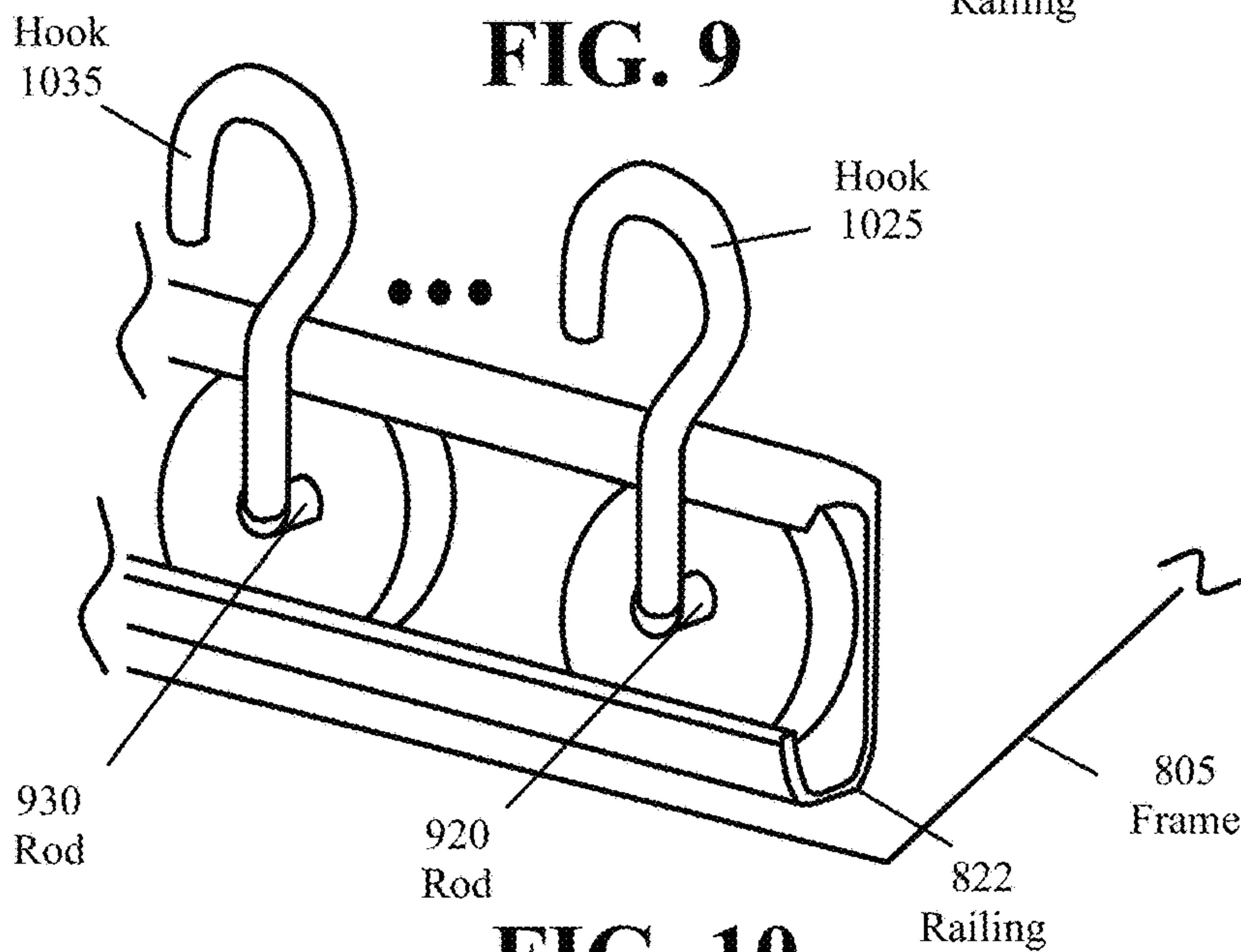


FIG. 10

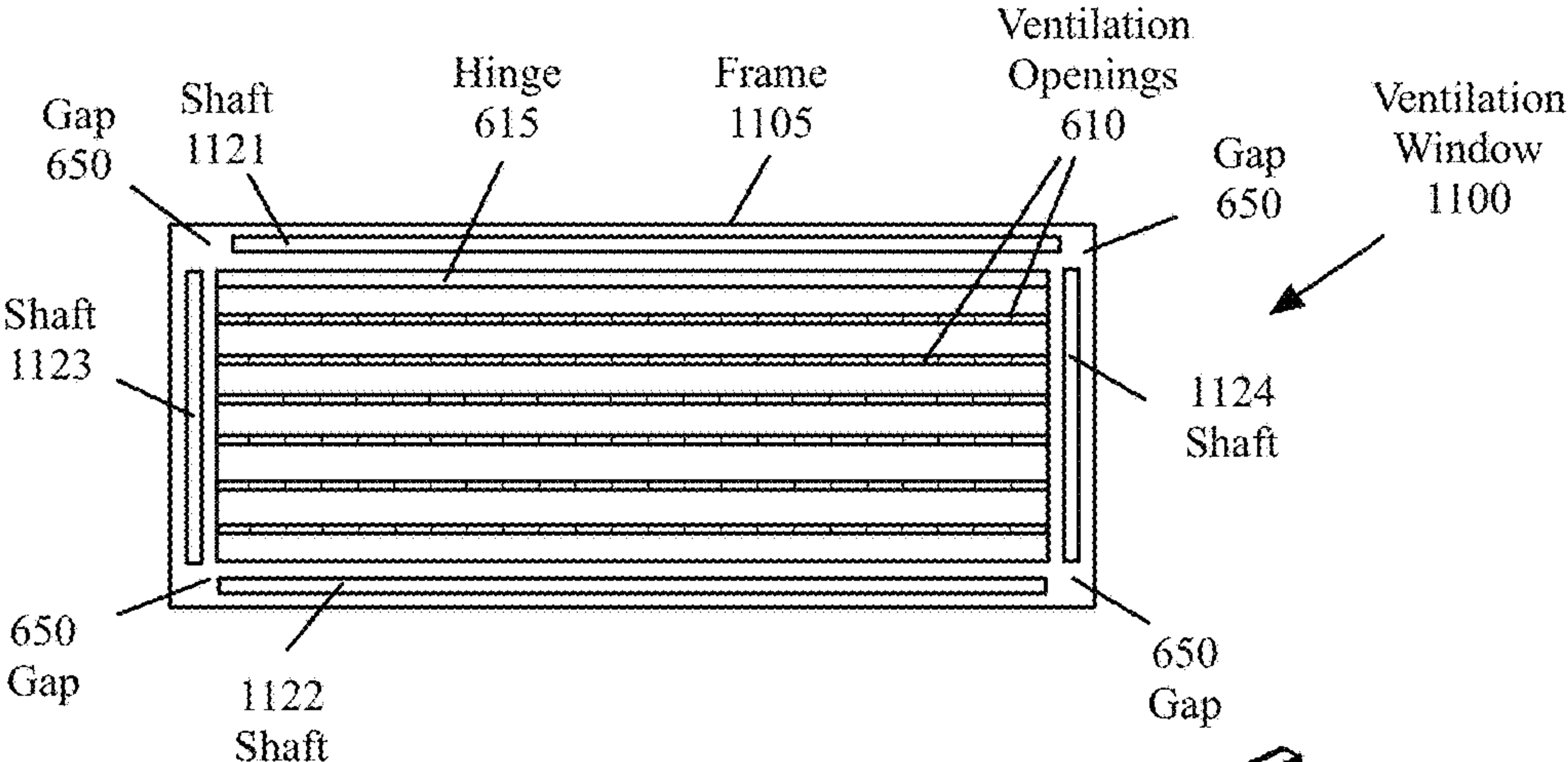


FIG. 11

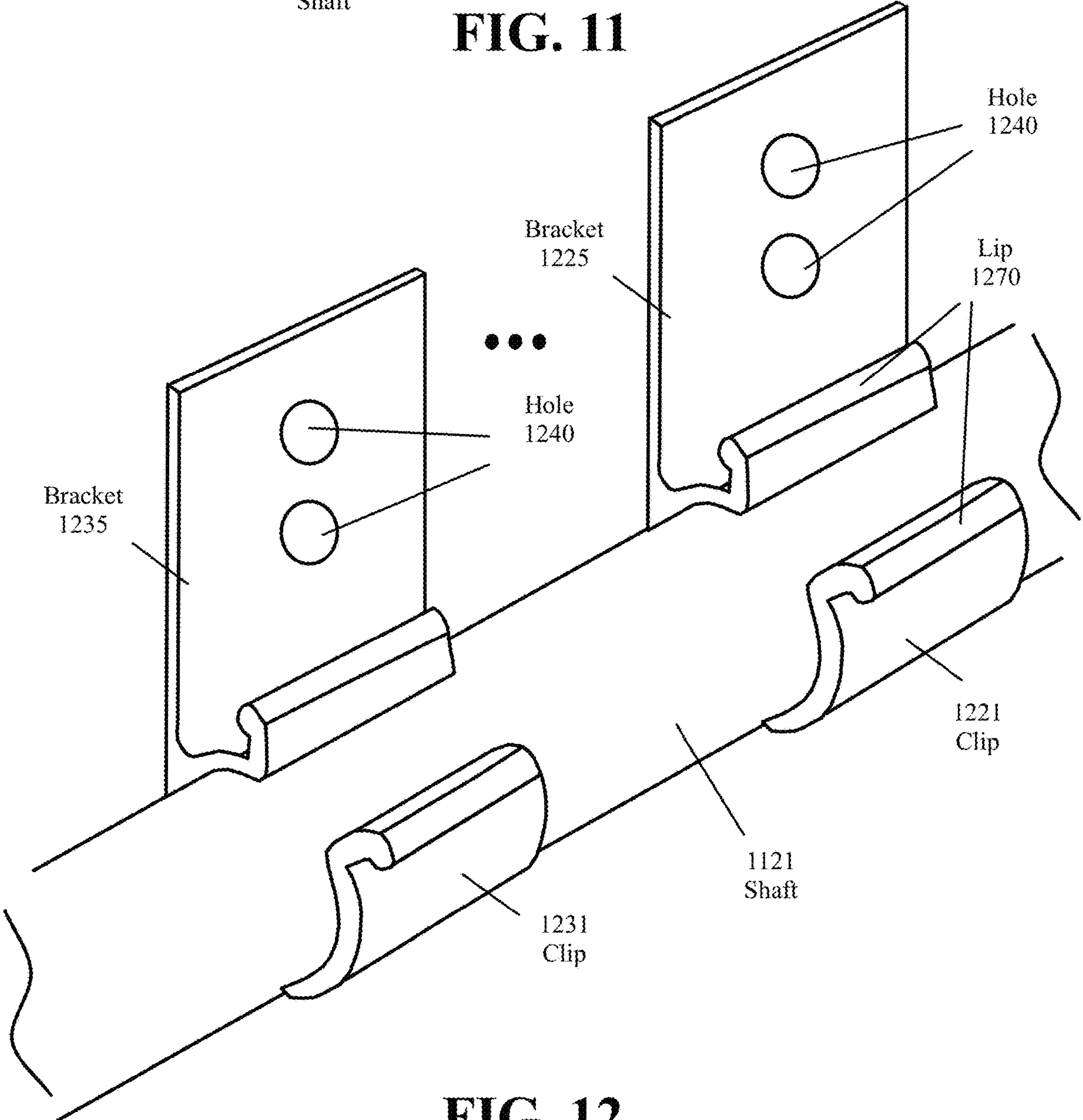


FIG. 12

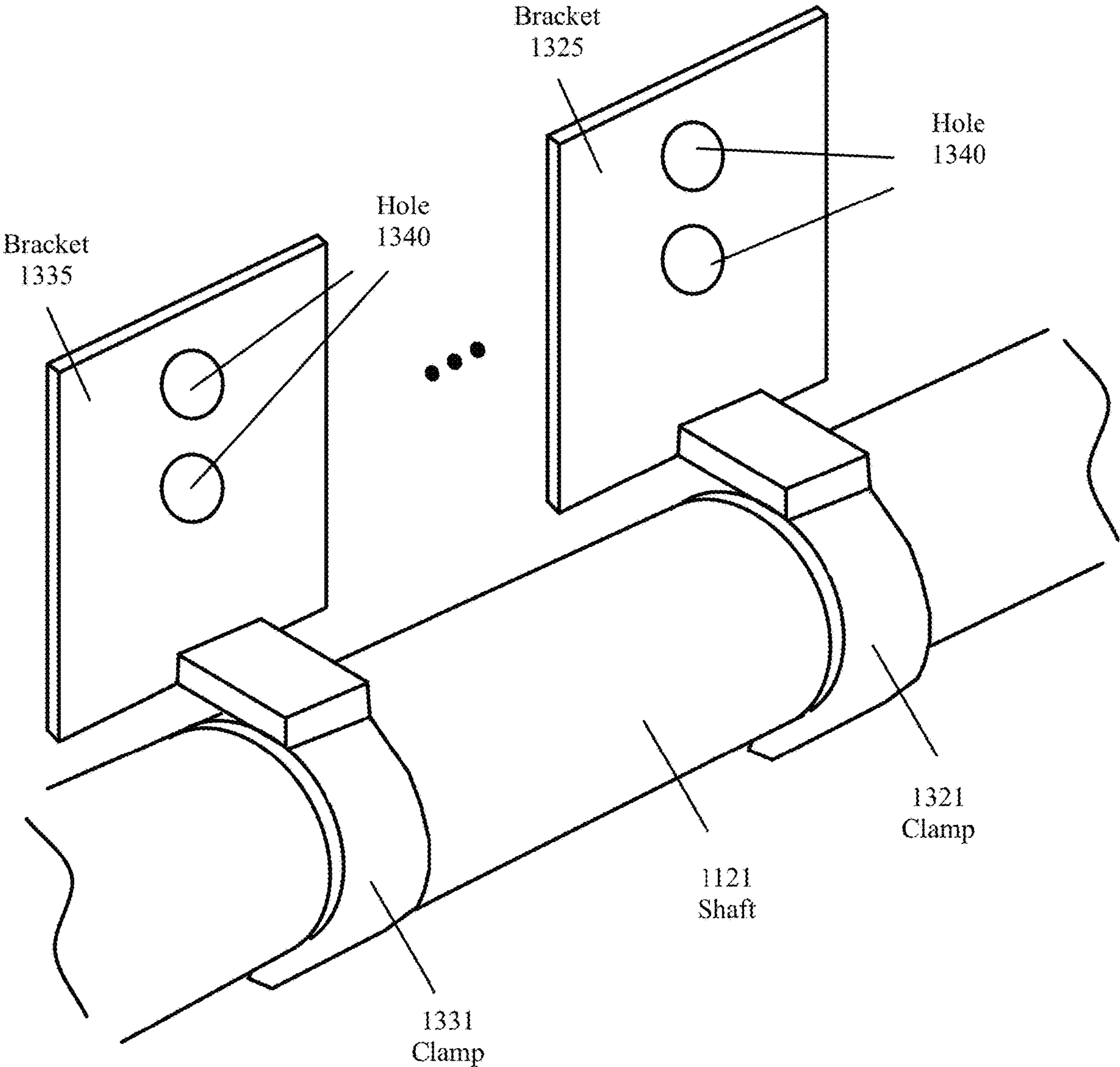


FIG. 13

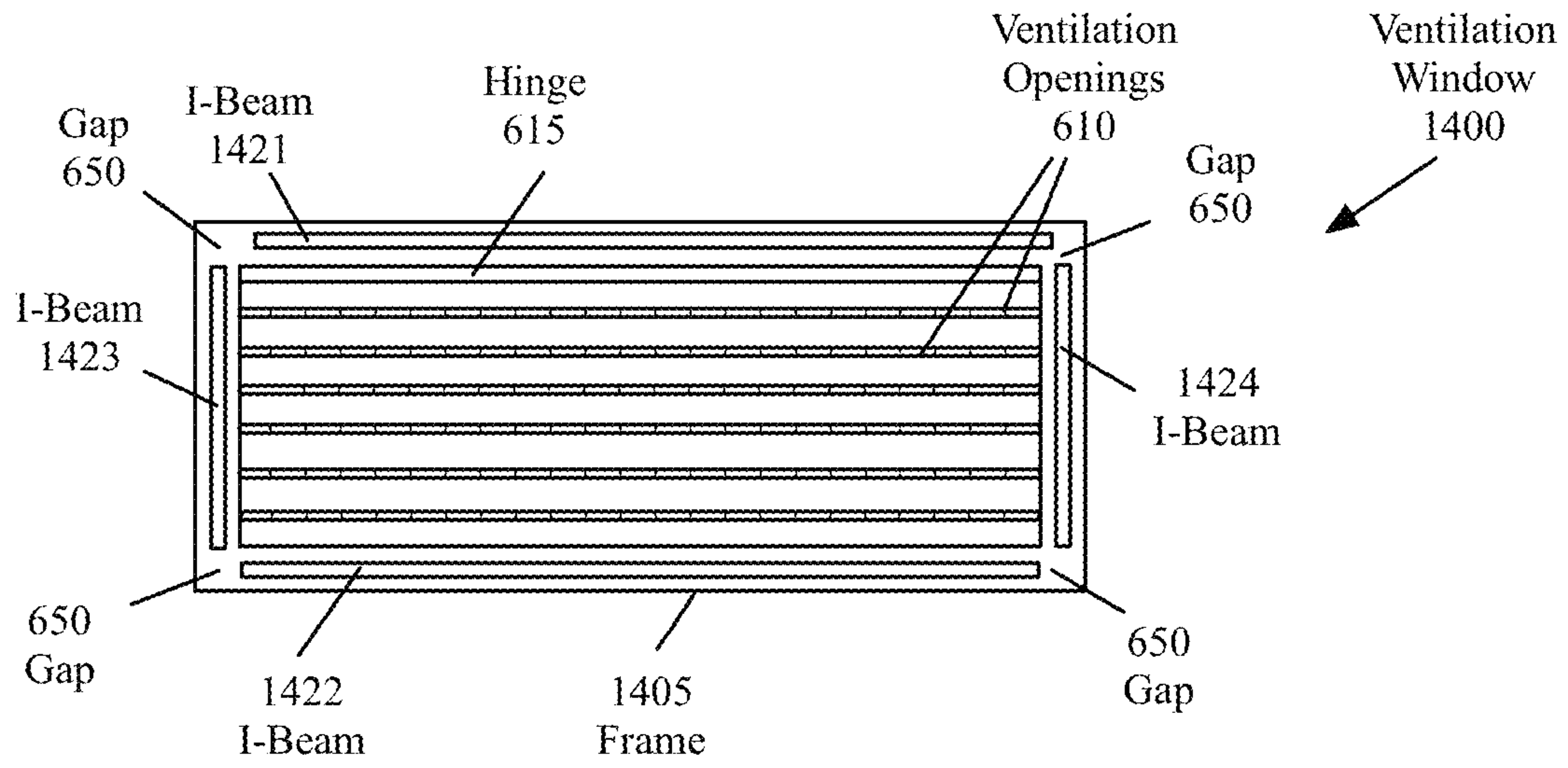


FIG. 14

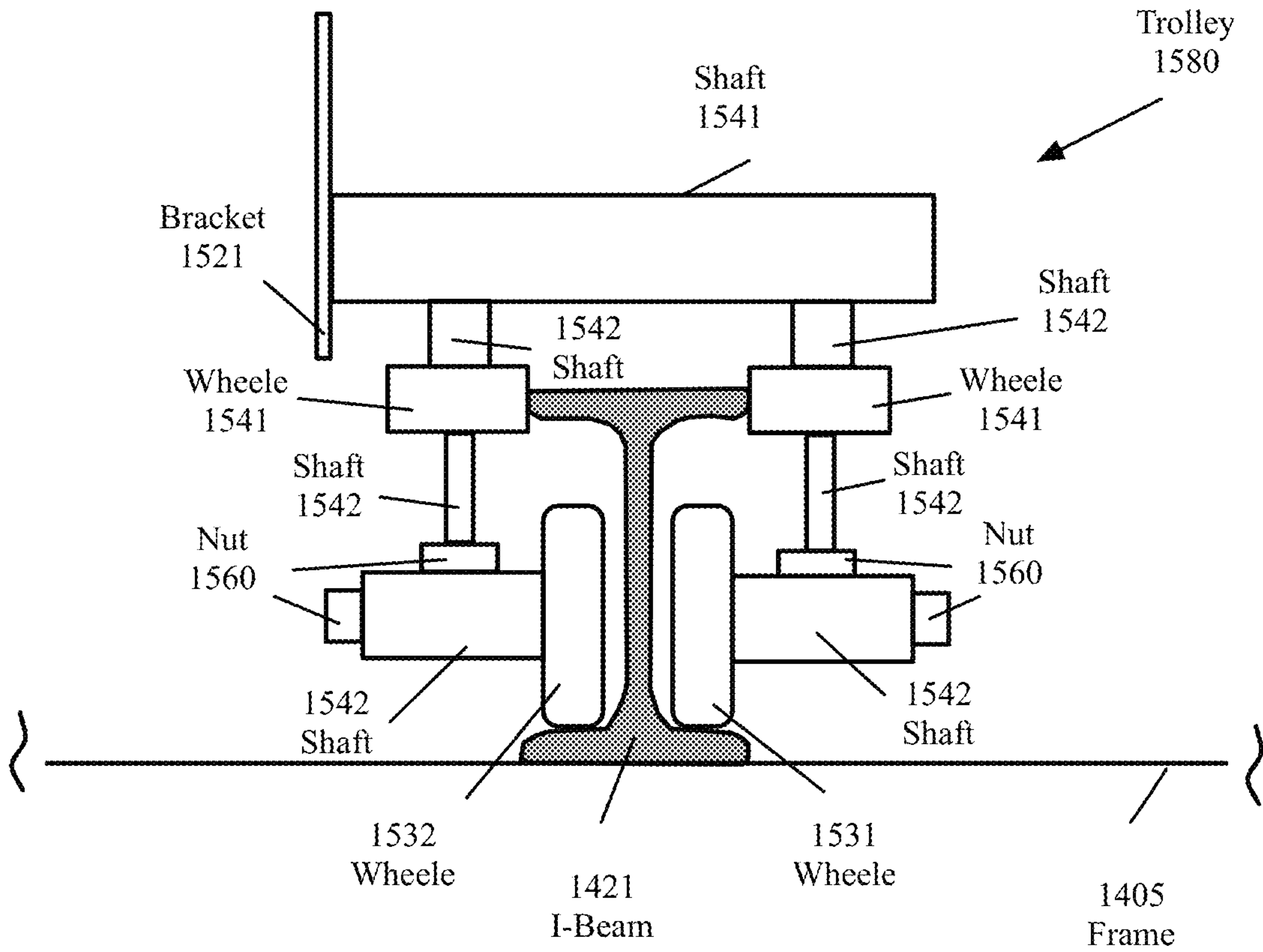


FIG. 15

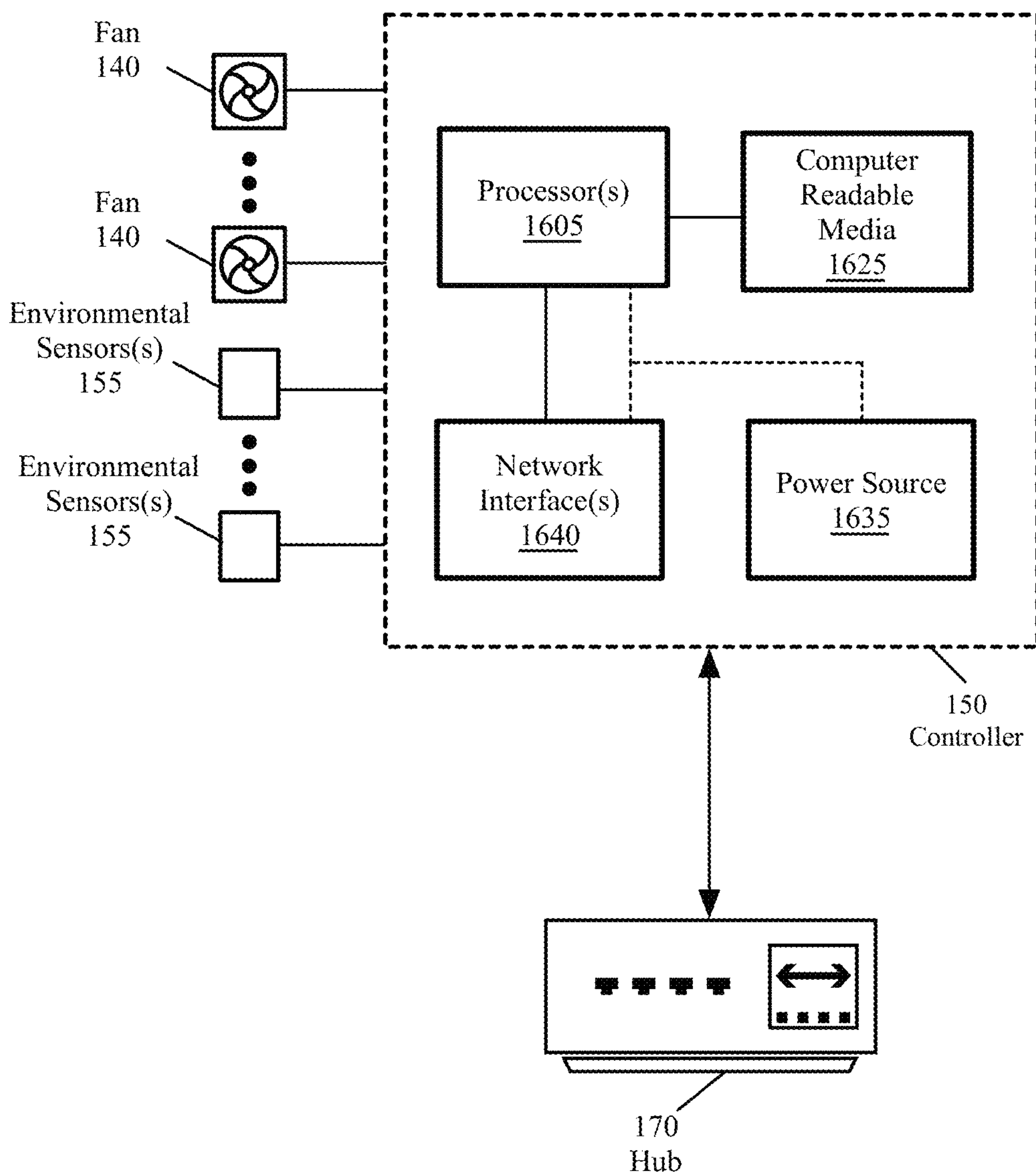


FIG. 16

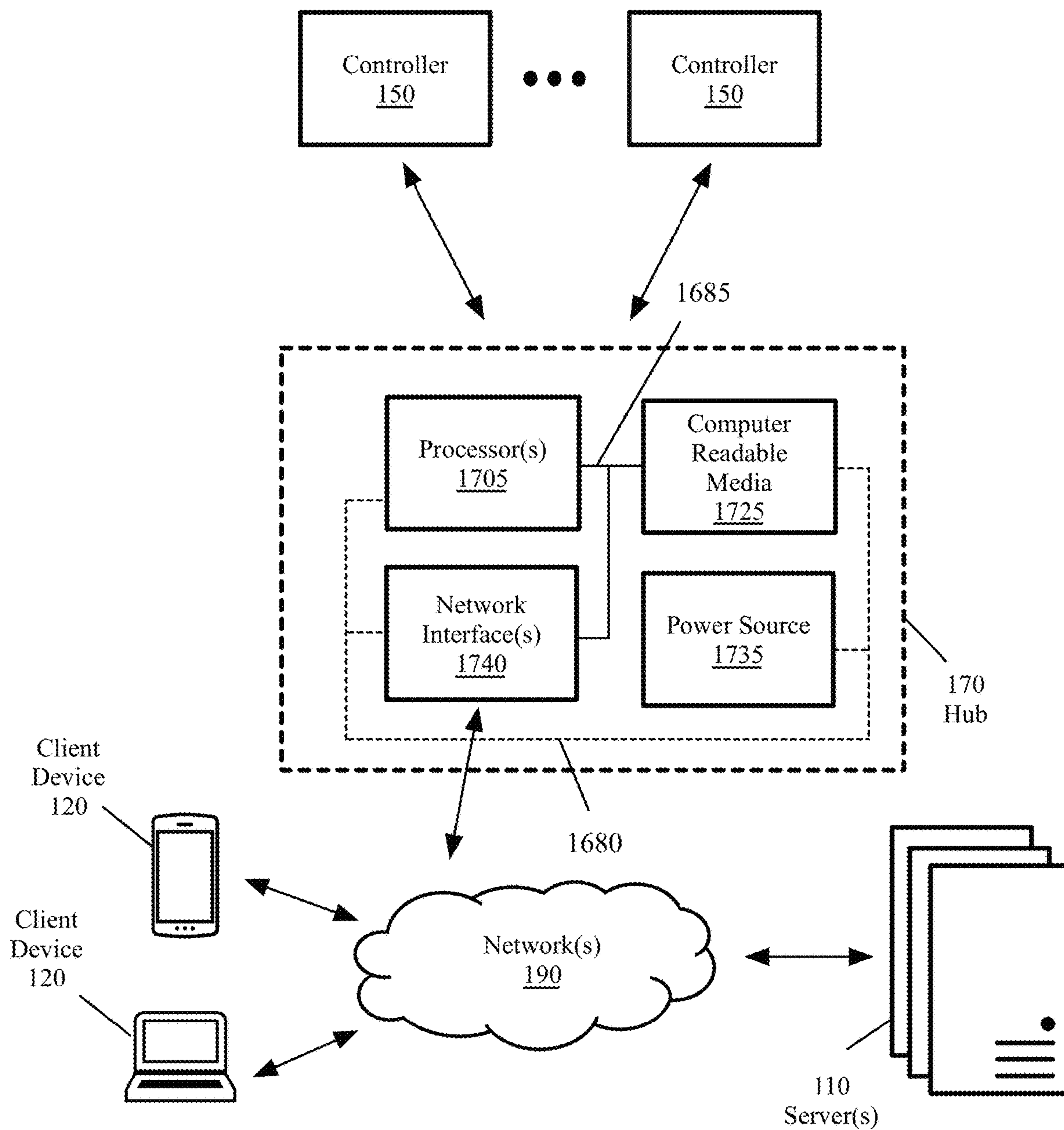


FIG. 17

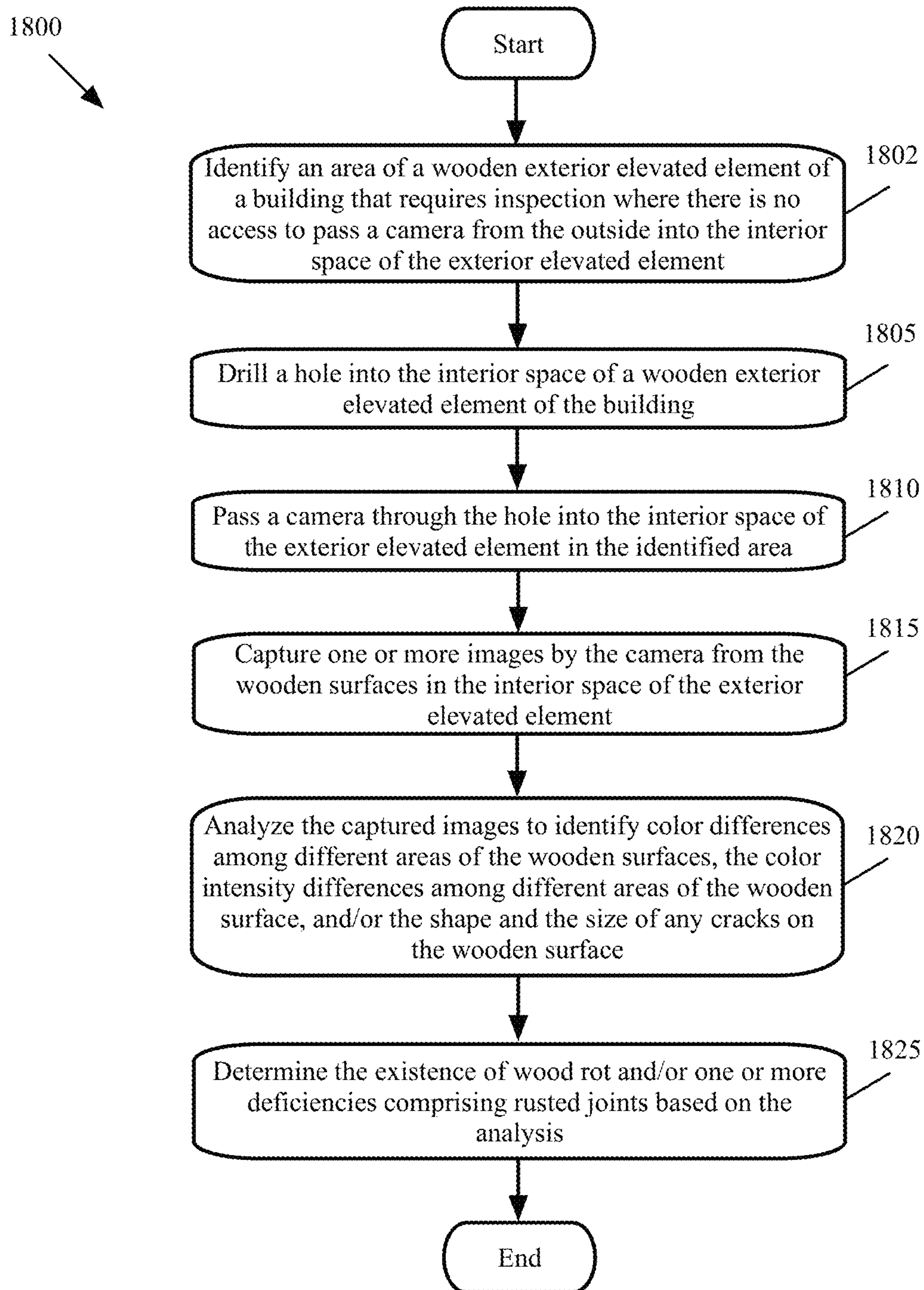


FIG. 18

1900

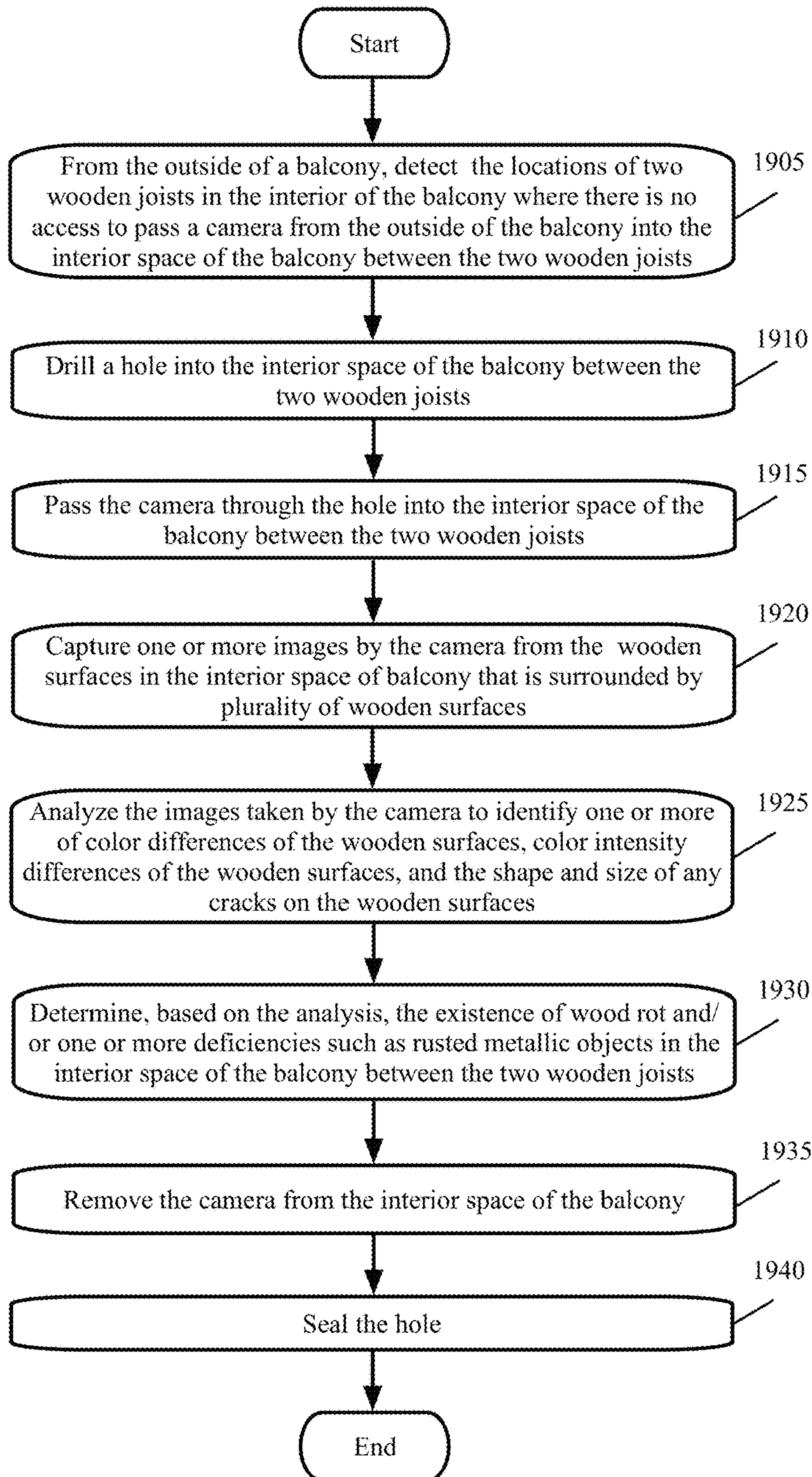


FIG. 19

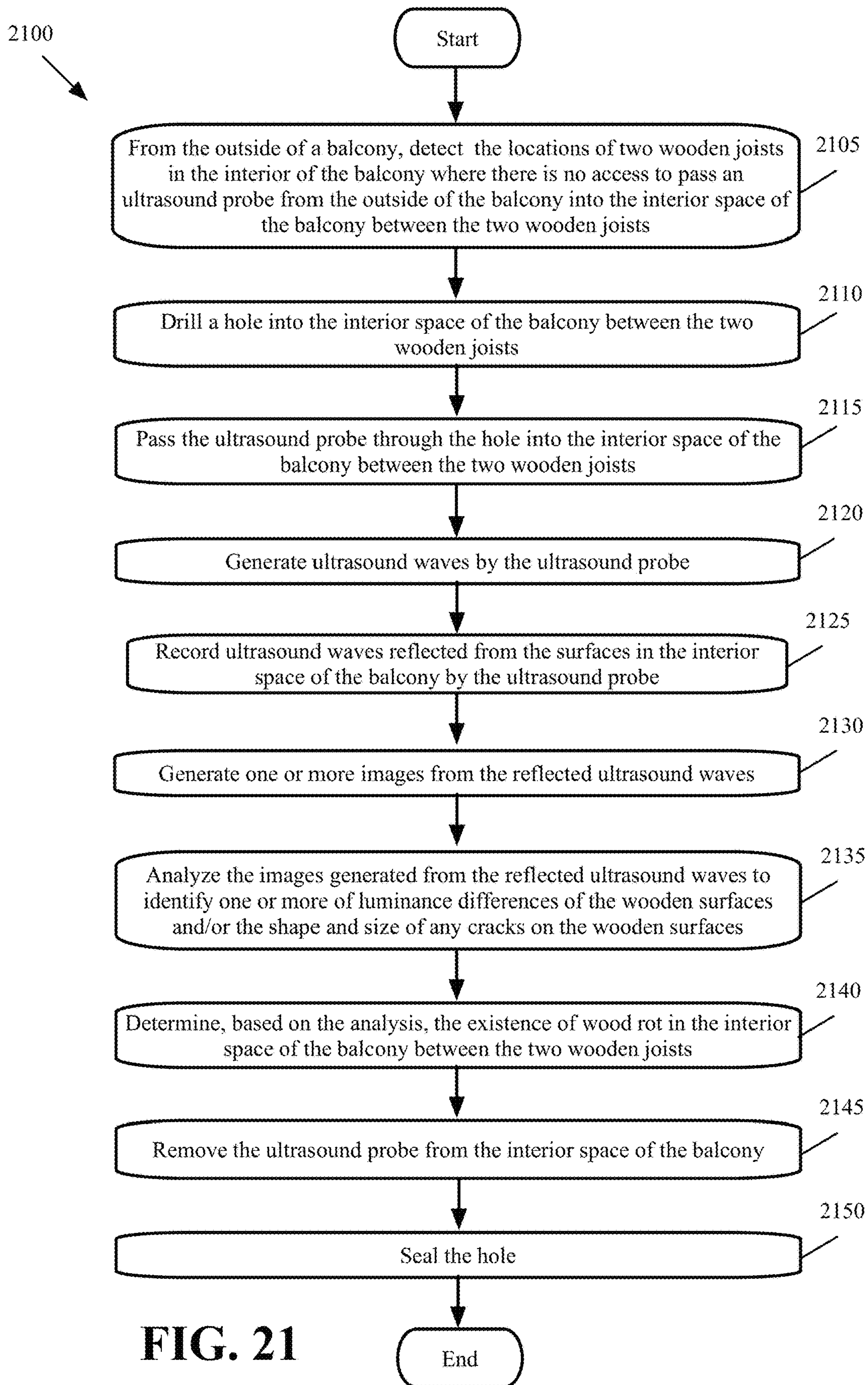


FIG. 21

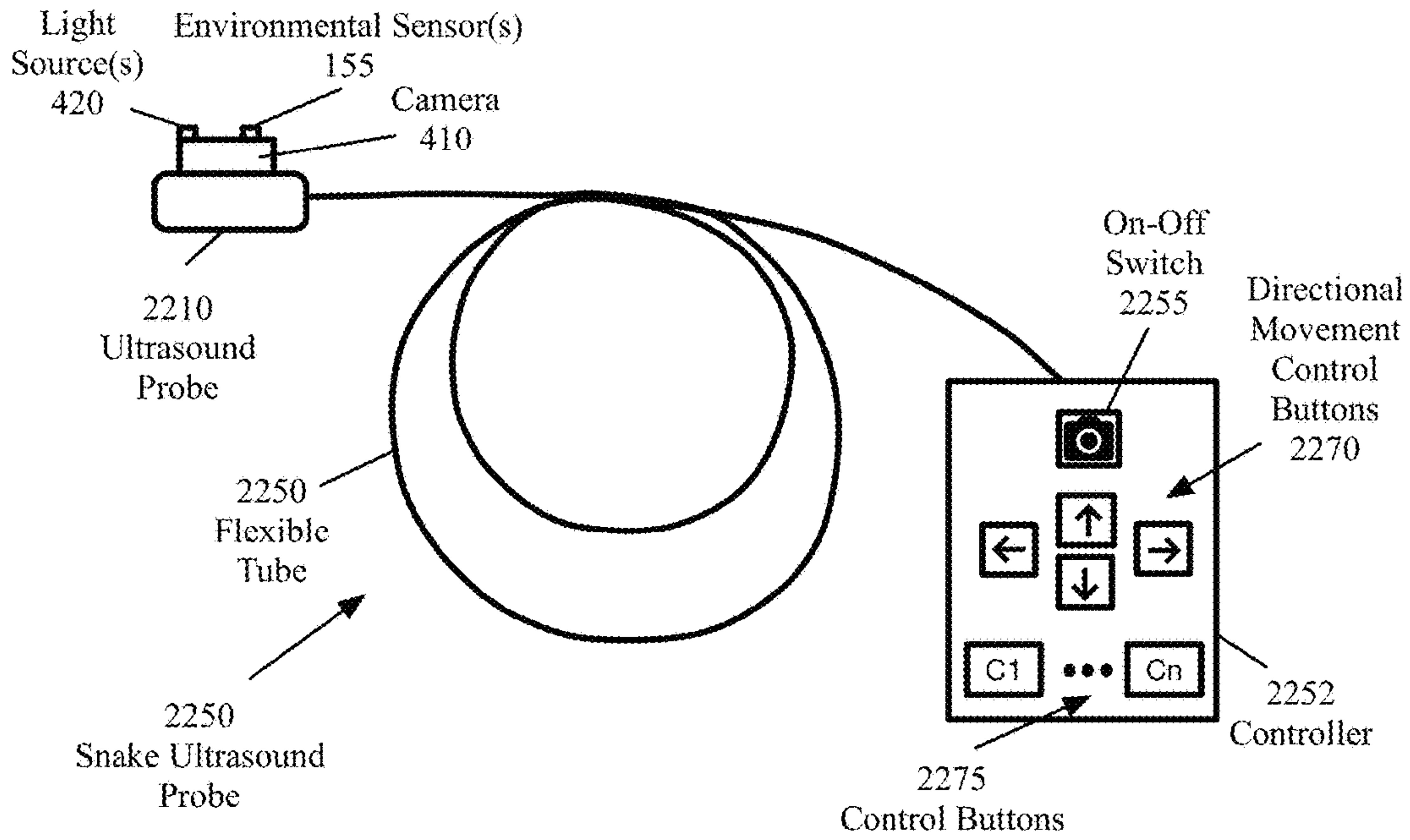


FIG. 22A

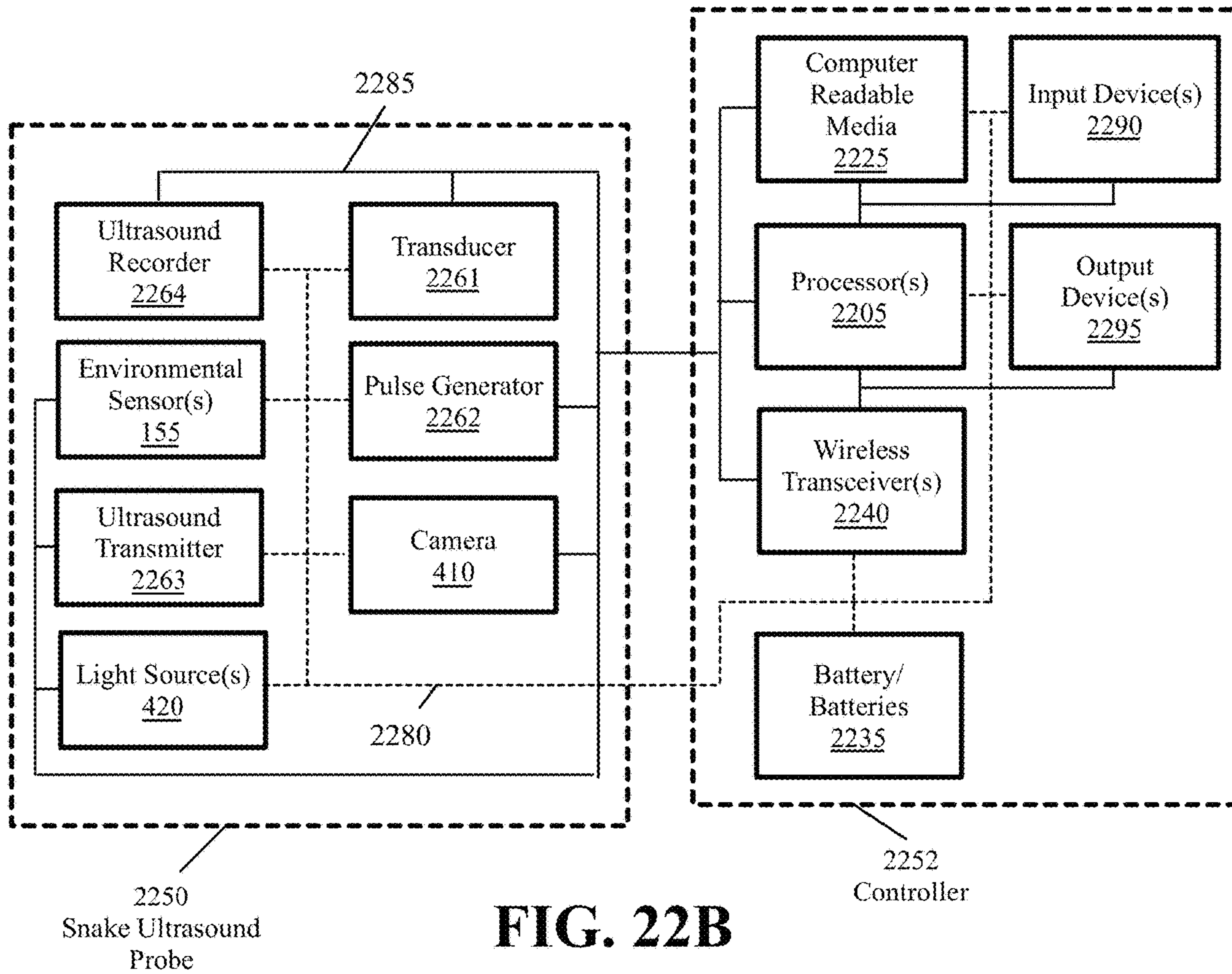


FIG. 22B

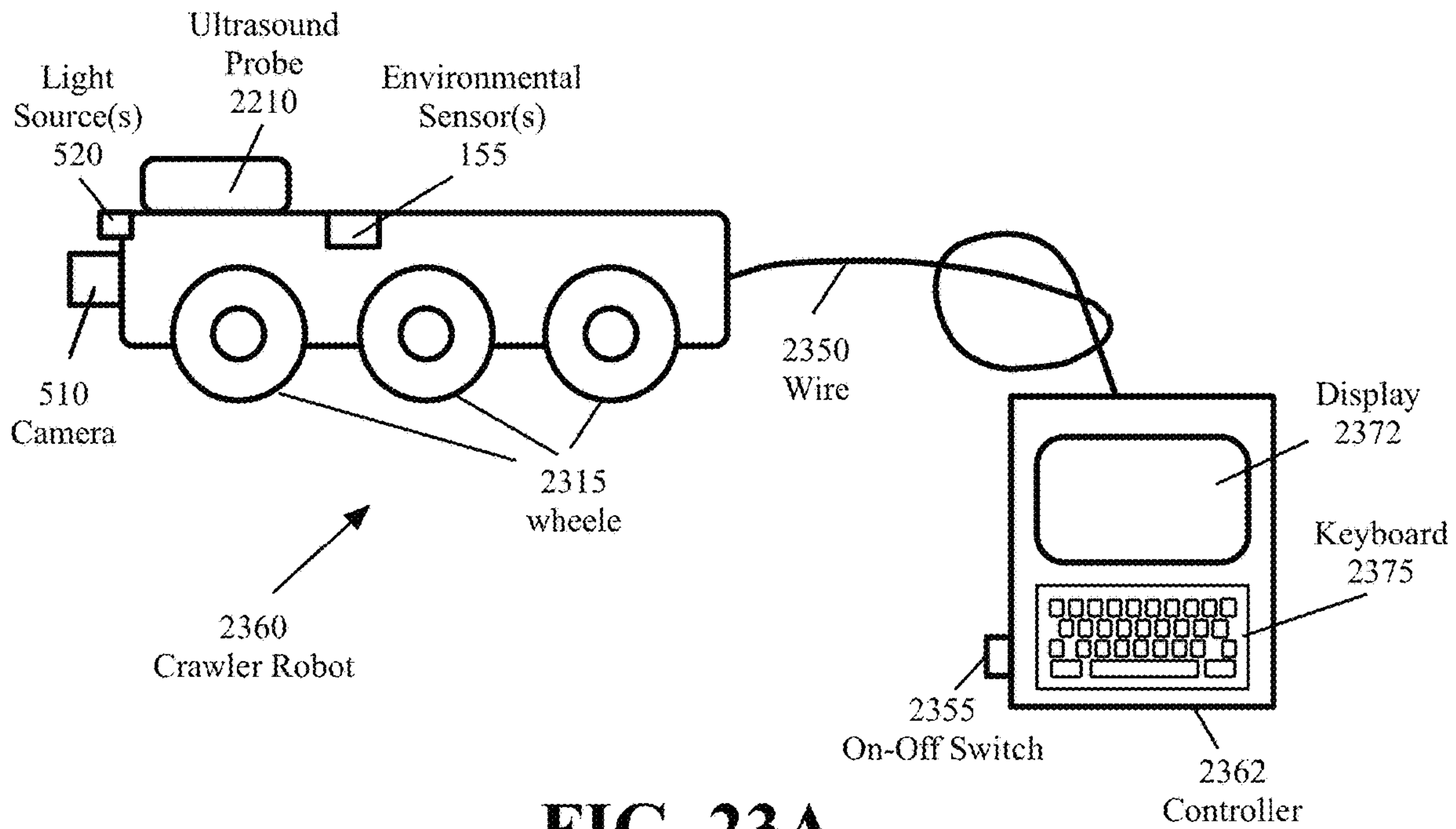


FIG. 23A

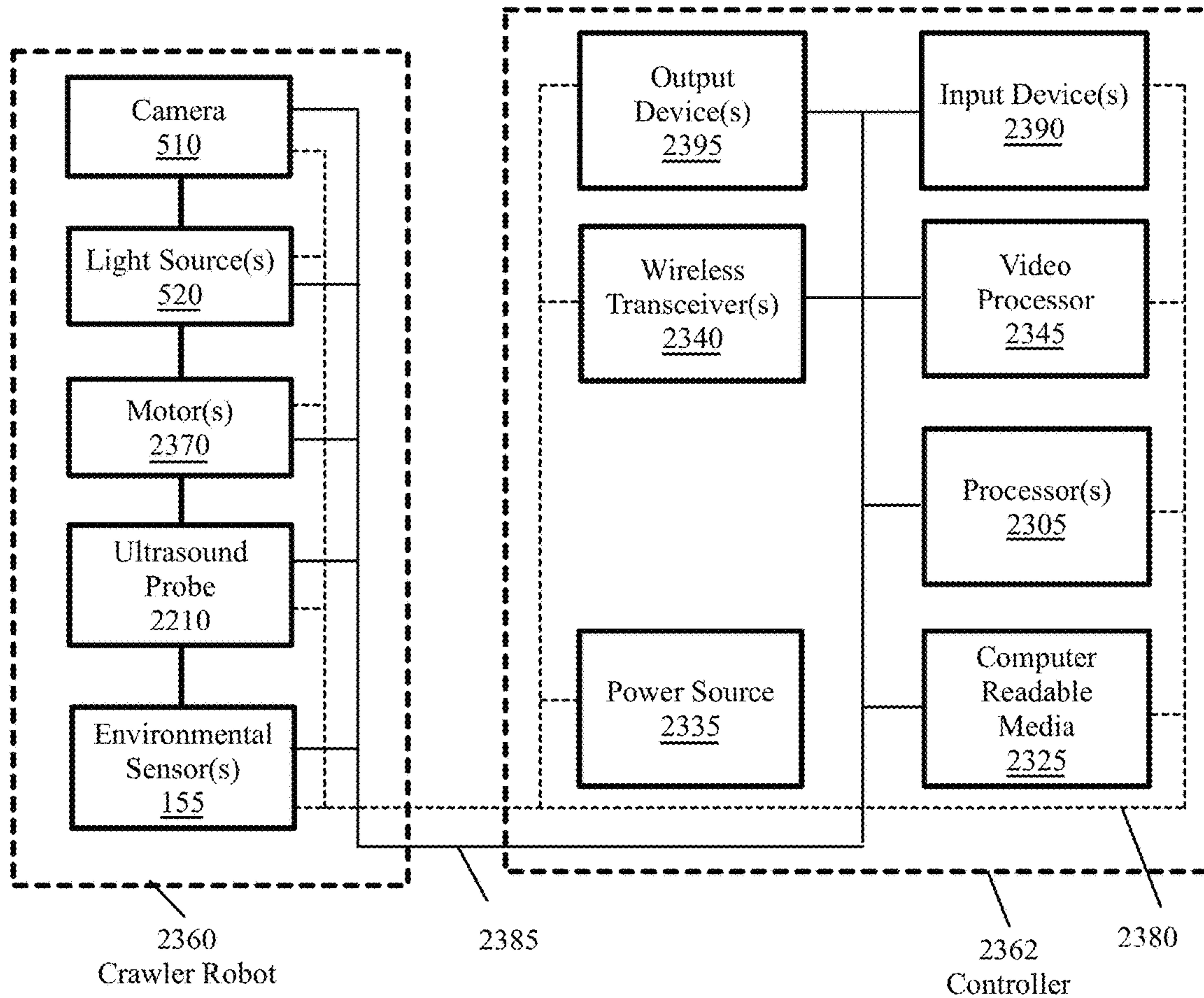


FIG. 23B

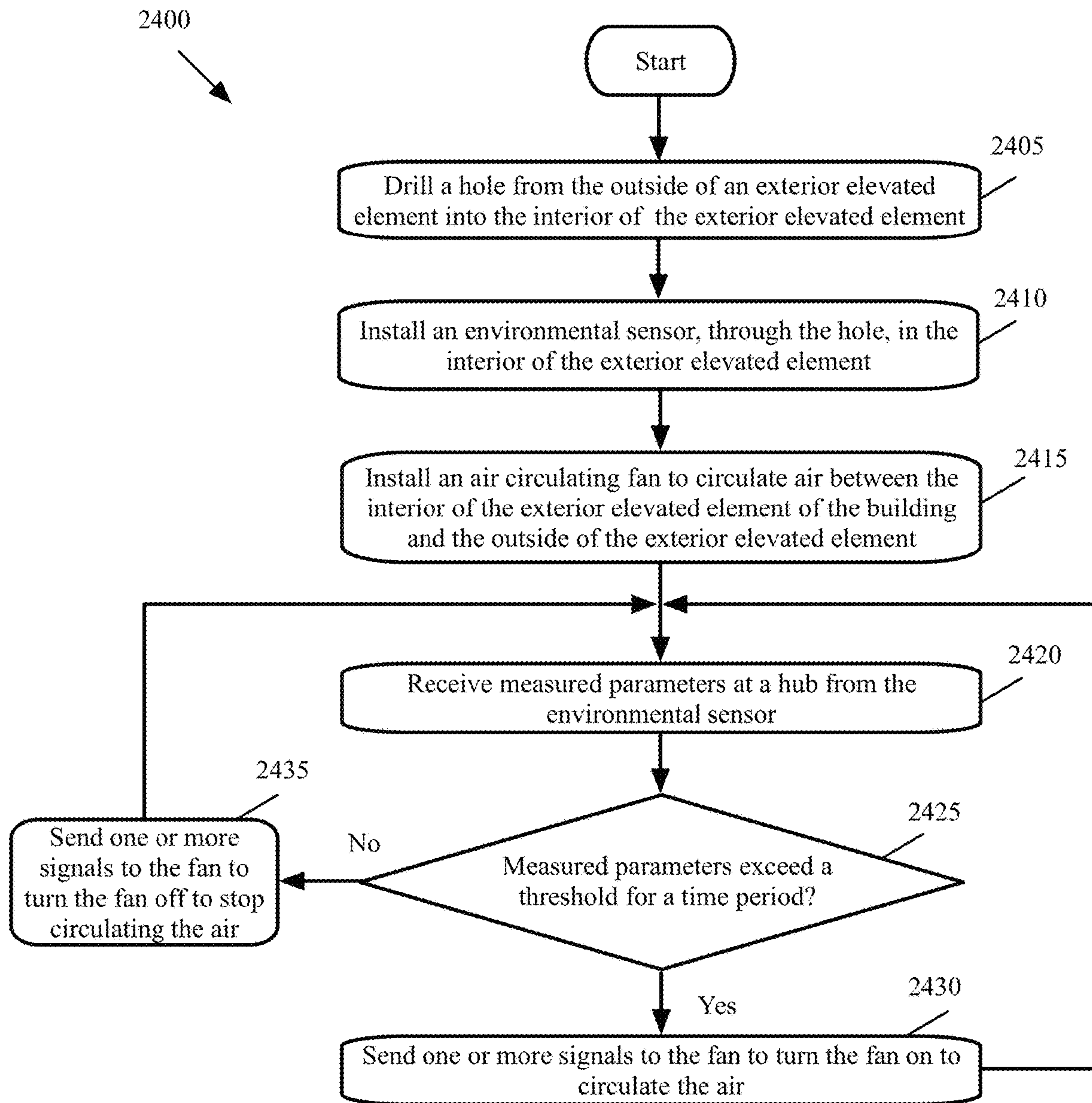


FIG. 24

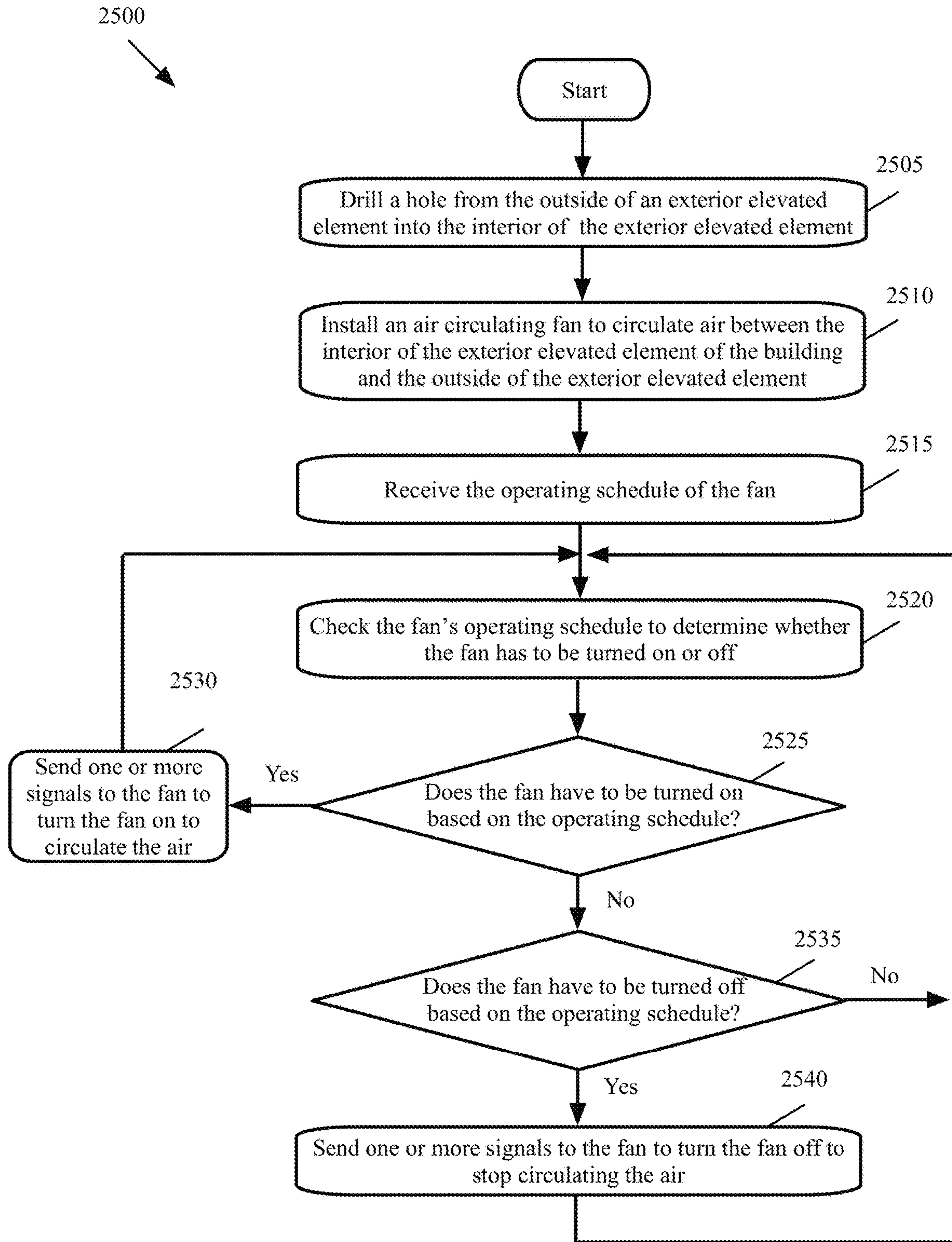


FIG. 25

2600
↙

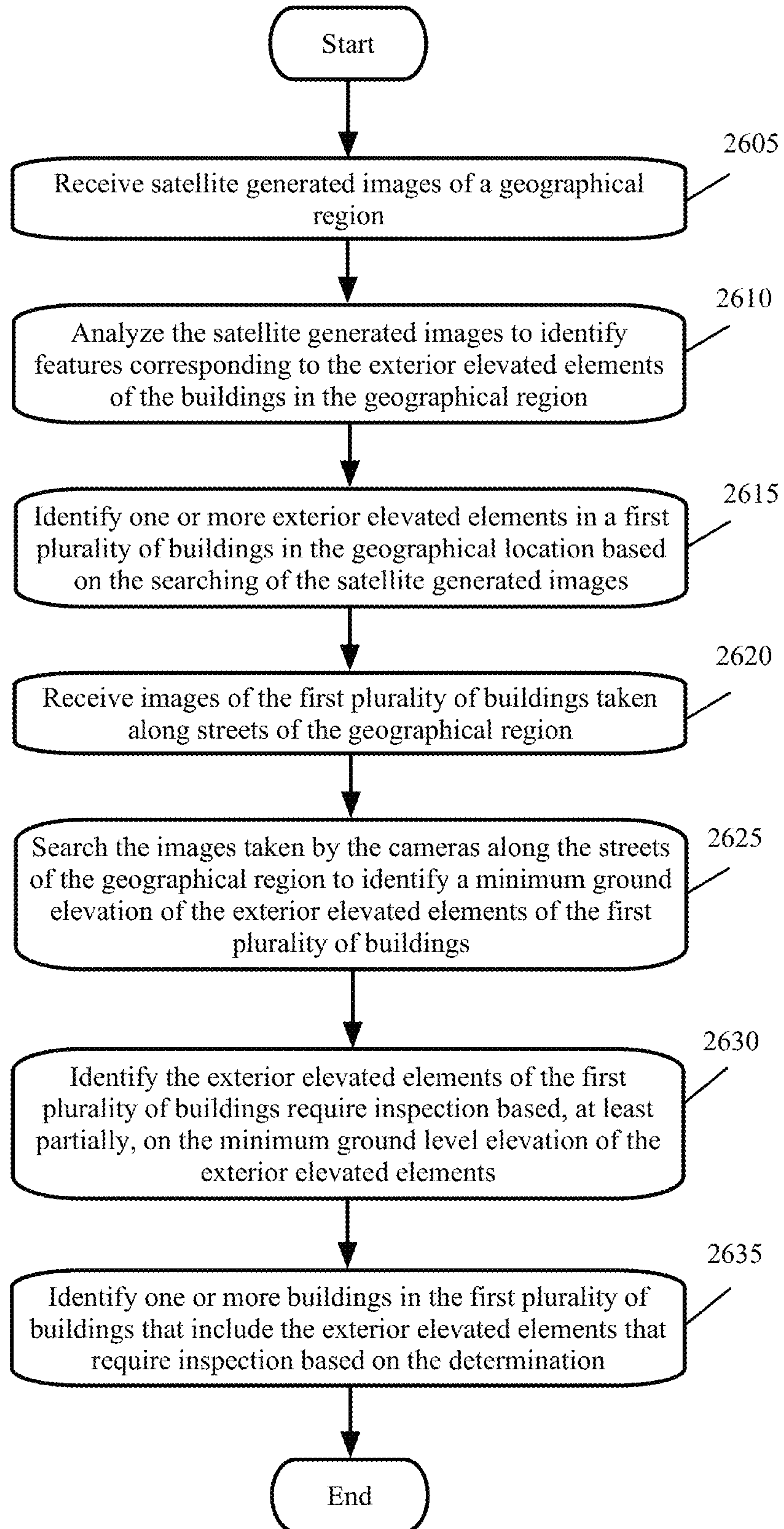


FIG. 26

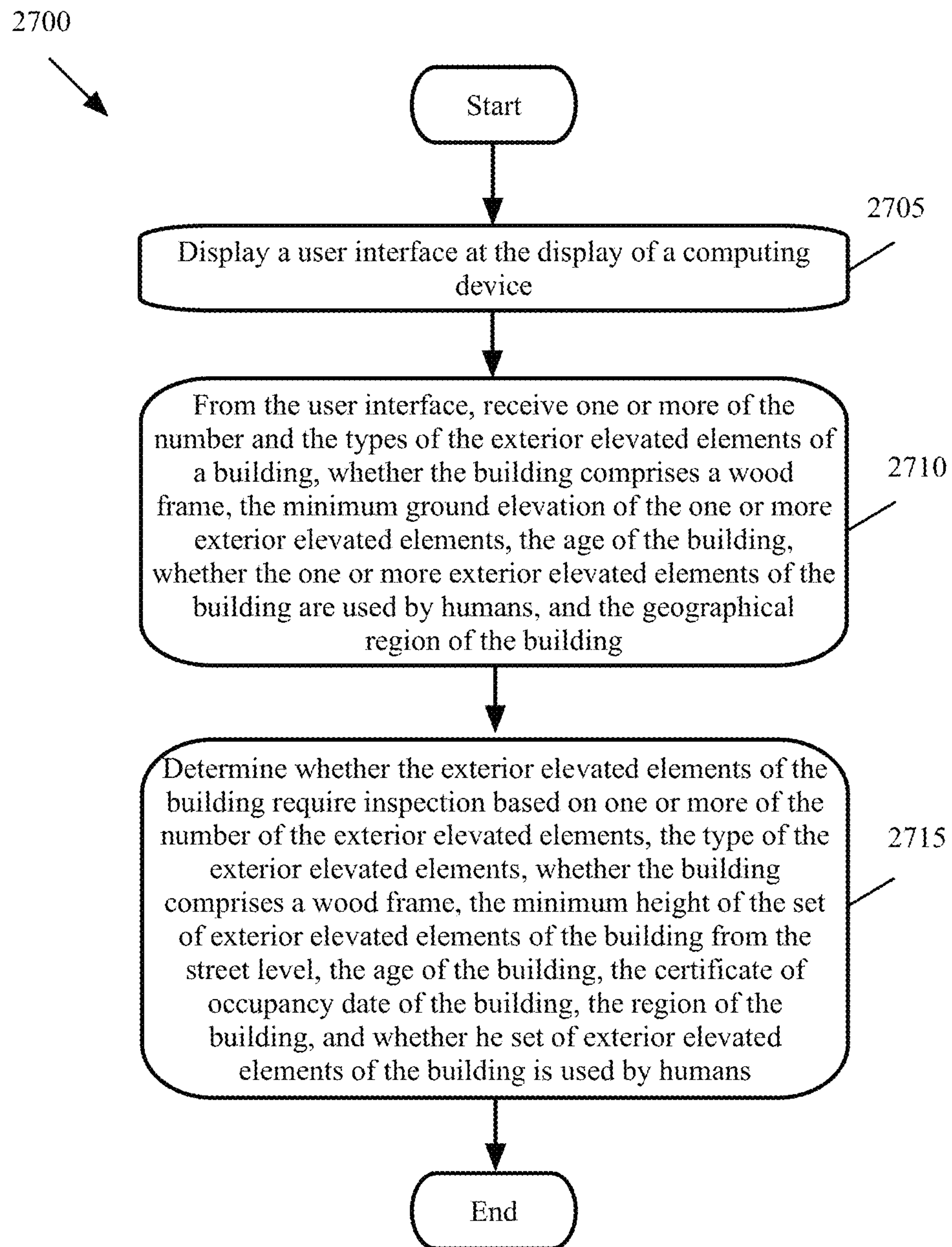


FIG. 27

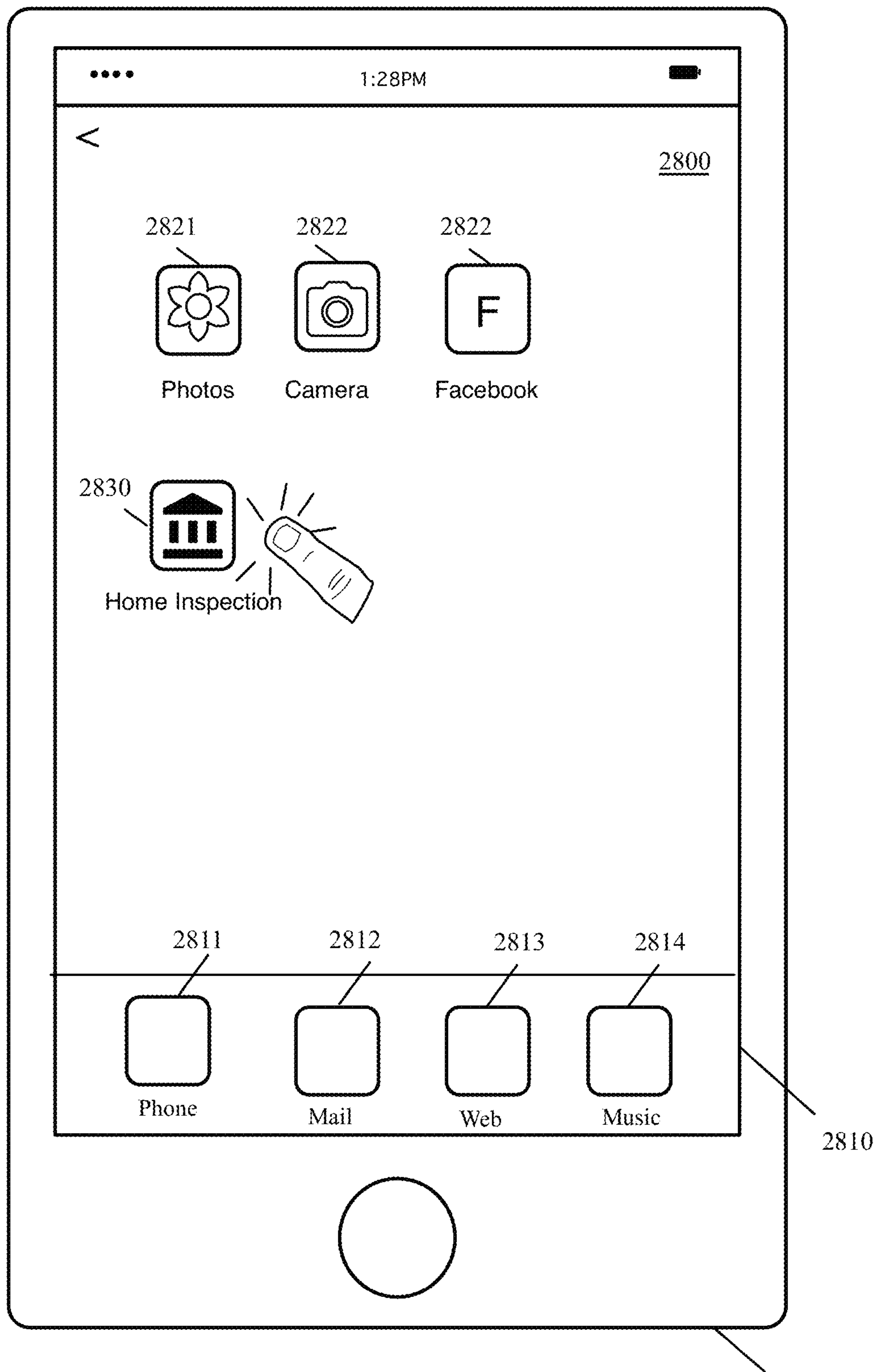


FIG. 28A

2801

120

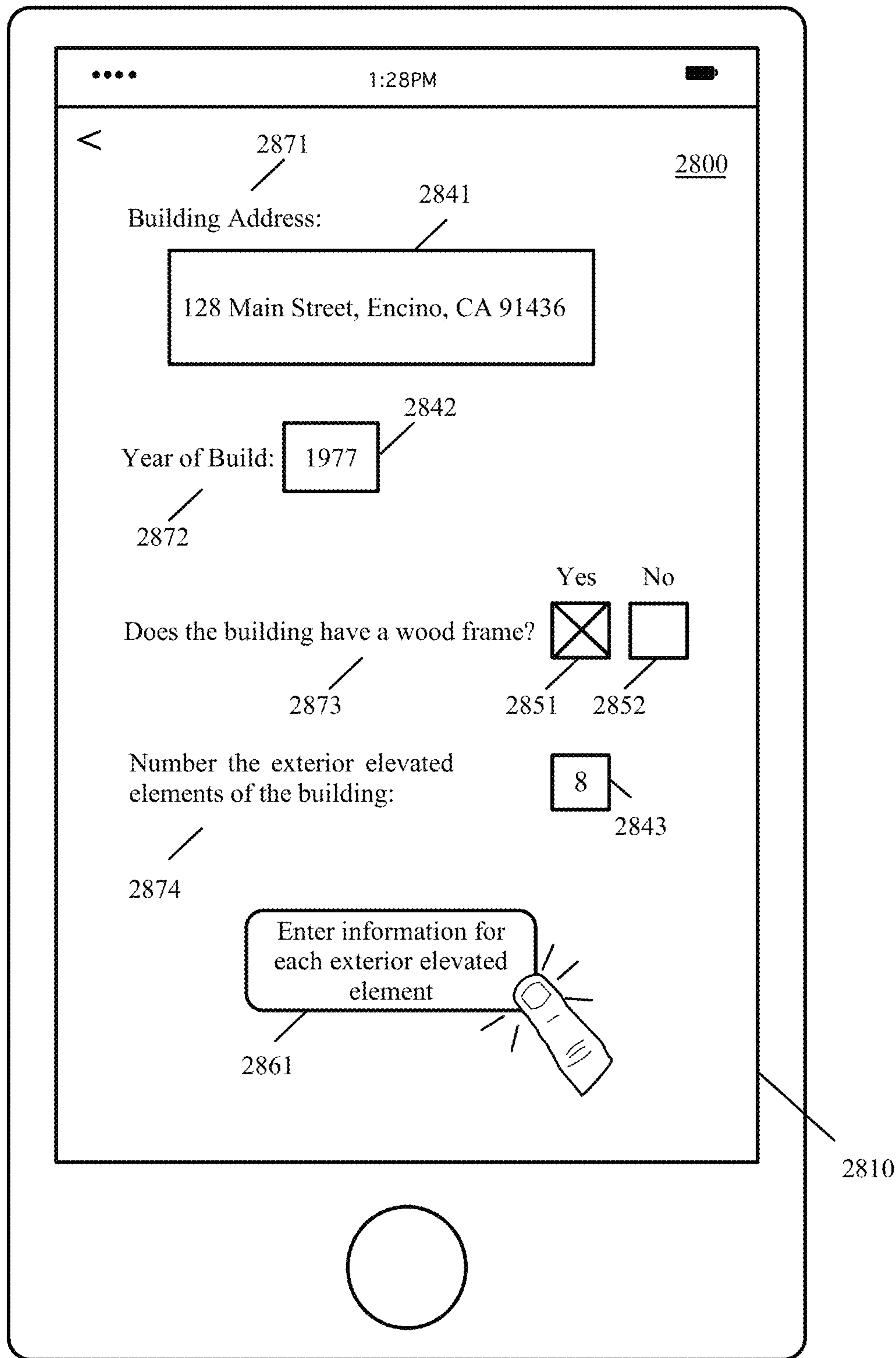


FIG. 28B

2802

1:28PM

2876 2881

Type of the exterior elevated element: 2800

2892 Balcony

2893 Porch

2894 Deck

2896 Stairway

2897 Walkway

2897 Landing

2882

Minimum ground elevation in feet: 2891

18

2883

Is the exterior elevated element used by humans:

Yes No

2898 2899

Enter information for another exterior elevated element

2875

2810

120

2803

FIG. 28C

120

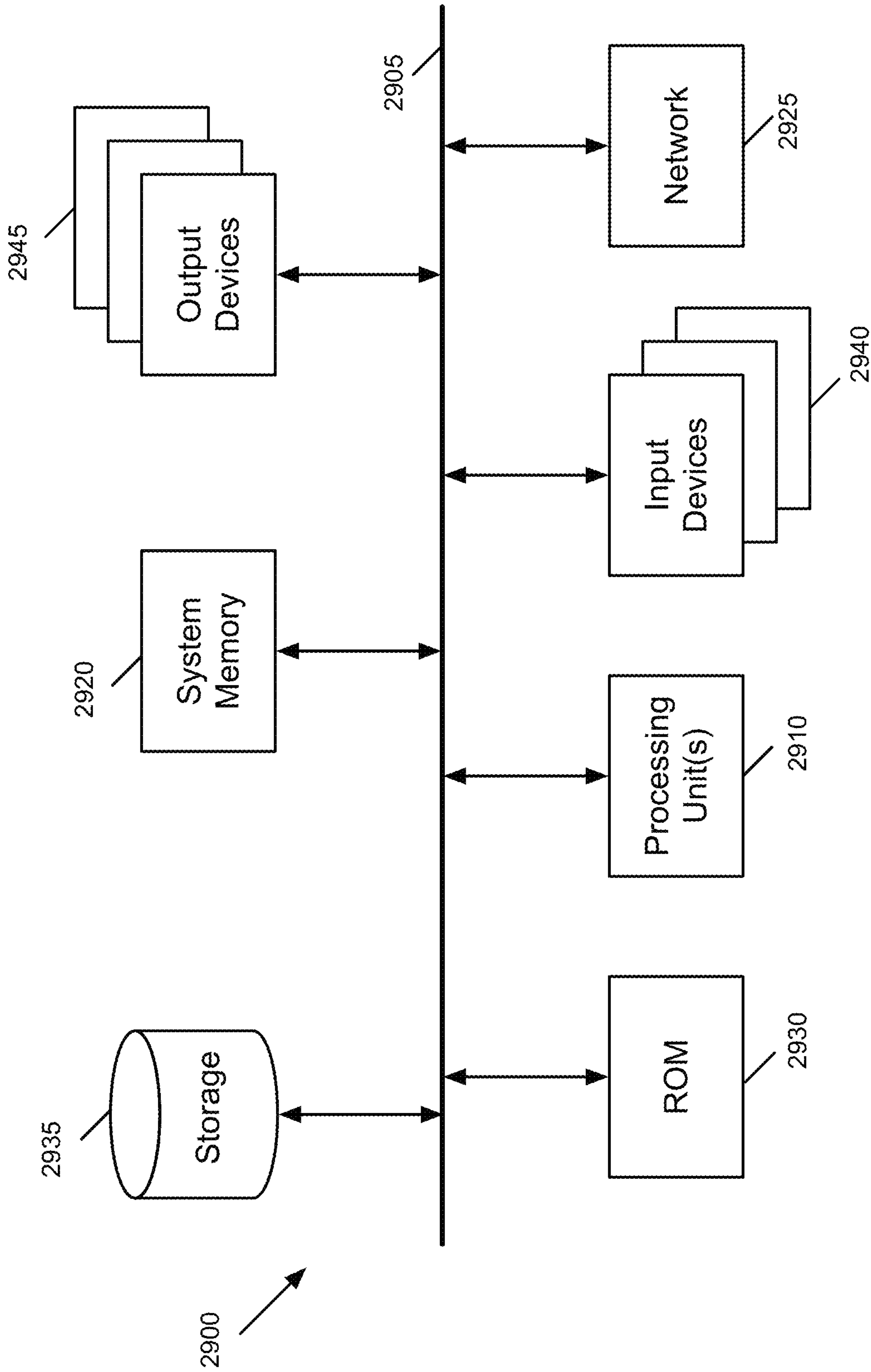


FIG. 29

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**SYSTEM AND METHOD FOR INSPECTING
AND MAINTAINING THE EXTERIOR
ELEVATED ELEMENTS OF BUILDING
STRUCTURES**

CLAIM OF BENEFIT TO PRIOR
APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 18/075,927, filed on Dec. 6, 2022. U.S. patent application Ser. No. 18/075,927 claims the benefit of U.S. Provisional Patent Application Ser. No. 63/292,078, filed on Dec. 21, 2021, and U.S. Provisional Patent Application Ser. No. 63/406,250, filed on Sep. 14, 2022. The contents of U.S. patent application Ser. No. 18/075,927, U.S. Provisional Patent Application 63/292,078, and U.S. Provisional Patent Application 63/406,250 are hereby incorporated by reference.

BACKGROUND

Wood is one of the most prevalent building materials. Several conditions such as wood rot and bolt and nail rust may affect the health of a wood frame building. Exterior elevated elements of a building such as decks, porches, balconies, stairways, walkways, landings, etc., may become deteriorated over time. Many of these deterioration conditions may occur to the beams, joists, bridging, ledgers, bolts, and nails inside of the exterior elevated elements of a building and may not be detectable by eye inspection.

BRIEF DESCRIPTION OF THE DRAWINGS

The various embodiments of the present system and method for inspecting and maintaining the exterior elevated elements of building structures now will be discussed in detail with an emphasis on highlighting the advantageous features. These embodiments depict the novel and non-obvious system and method for inspecting and maintaining the exterior elevated elements of building structures shown in the accompanying drawings, which are for illustrative purposes only. These drawings include the following figures, in which like numerals indicate like parts:

FIGS. 1A-1B are functional diagrams illustrating an example embodiment of a system for inspecting and maintaining exterior elevated elements of building structures, according to various aspects of the present disclosure;

FIG. 2 shows different components of an exemplary exterior elevated element of a building structure, according to prior art;

FIG. 3 is a perspective view of a hole saw, according to prior art;

FIG. 4A is a schematic front view of a custom-made snake camera and the associated controller, according to different aspects of the present disclosure;

FIG. 4B is a functional block diagram of the components of the custom-made snake camera of FIG. 4A, according to different aspects of the present disclosure;

FIG. 5A is a schematic top view of a custom-made crawler robot and the associated controller, according to different aspects of the present disclosure;

FIG. 5B is a functional block diagram of the components of custom-made crawler robot of FIG. 5A, according to different aspects of the present disclosure;

FIG. 6A is a bottom view and FIG. 6B is a top view of a ventilation window that may be installed on the underside of

2

an exterior elevated element of a building, according to various aspects of the present embodiments;

FIG. 7 illustrates a portion of a pair of railings of FIG. 6B, according to various aspects of the present disclosure;

FIG. 8 is a bottom view of an alternative ventilation window that may be installed on the underside of an exterior elevated element of a building, according to various aspects of the present embodiments;

FIG. 9 illustrates a portion of a railing of FIG. 8, according to various aspects of the present disclosure;

FIG. 10 illustrates a portion of a railing of FIG. 8, according to various aspects of the present disclosure;

FIG. 11 is a bottom view of an alternative ventilation window that may be installed on the underside of an exterior elevated element of a building, according to various aspects of the present embodiments;

FIG. 12 illustrates a portion of a shaft of FIG. 11, according to various aspects of the present disclosure;

FIG. 13 illustrates a portion of a shaft of FIG. 11, according to various aspects of the present disclosure;

FIG. 14 is a bottom view of an alternative ventilation window that may be installed on the underside of an exterior elevated element of a building, according to various aspects of the present embodiments;

FIG. 15 illustrates a front view of an I-beam of FIG. 14, according to various aspects of the present disclosure;

FIG. 16 is a functional diagram illustrating a controller that controls one or more fans and/or one or more environmental sensors of an exterior elevated element of a building, according to various aspects of the present disclosure;

FIG. 17 is a functional diagram illustrating a hub that is used to communicate with one or more controllers associated with the exterior elevated elements of a building, according to various aspects of the present disclosure;

FIG. 18 is a flowchart illustrating an example process for inspecting the interior space of a wooden exterior elevated element of a building, according to various aspects of the present disclosure;

FIG. 19 is a flowchart illustrating an example process for drilling a hole into the area between two interior joists of a balcony to provide access to pass a camera to inspect the area between the two joists, according to various aspects of the present disclosure;

FIG. 20 shows the closed areas that may be formed between the joists in the interior of a balcony where a hole has to be drilled to pass a camera inside, according to various aspects of the present disclosure;

FIG. 21 is a flowchart illustrating an example process for drilling a hole into the area between two interior joists of a balcony to provide access to pass an ultrasound probe to inspect the area between the two joists, according to various aspects of the present disclosure;

FIG. 22A is a schematic front view of a custom-made snake ultrasound probe and the associated controller, according to different aspects of the present disclosure;

FIG. 22B is a functional block diagram of the components of the custom-made snake ultrasound probe of FIG. 22A, according to different aspects of the present disclosure;

FIG. 23A is a schematic front view of a custom-made crawler robot and the associated ultrasound probe and controller, according to different aspects of the present disclosure;

FIG. 23B is a functional block diagram of the components of custom-made crawler robot of FIG. 23A, according to different aspects of the present disclosure;

FIG. 24 is a flowchart illustrating an example process for installing a fan in the interior space of an exterior elevated

element of a building and operating the fan based on parameters measured by an environmental sensor, according to various aspects of the present disclosure;

FIG. 25 is a flowchart illustrating an example process for installing a fan in the interior space of an exterior elevated element of a building and operating the fan based on an operating schedule, according to various aspects of the present disclosure;

FIG. 26 is a flowchart illustrating an example process for identifying building with exterior elevated elements that may require inspection, according to various aspects of the present disclosure;

FIG. 27 is a flowchart illustrating an example process for identifying building with exterior elevated elements that may require inspection through a user interface of an electronic device, according to various aspects of the present disclosure;

FIGS. 28A-28C illustrate a schematic front view of a client device that may include an application program for determining whether the exterior elevated elements of a building require inspection, according to various aspects of the present disclosure; and

FIG. 29 conceptually illustrates an electronic system with which some embodiments of the invention are implemented.

DETAILED DESCRIPTION

One aspect of the present embodiments includes the realization that the traditional eye inspection of the exterior elevated elements of a building may not reveal the health condition of the beams, joist, bridging, legers, bolts, and nails that are inside these elevated elements. The eye inspection of these exterior elements may require demolishing a portion of these structures that is large enough to allow eye inspection. In addition, once an exterior elevated element is inspected, and is repaired if damaged, there is no system and method for maintaining the health of the elevated element and preventing future wood rot to the wood and rust to the bolts and nails inside the structure. Furthermore, there is no automatic method of identifying buildings that include exterior elevated elements that may be subject to government required inspections.

The present embodiments, as described in detail below, solve the above-mentioned problems by providing a method and system for inspecting and maintaining the exterior elevated elements building structures, such as decks, porches, balconies, stairways, walkways, landings, etc., for wood rot and for the health condition of joists, beams, foundation, etc. Inspections may be required by different state and municipal governments and/or may be requested by homeowner associations, owners, lenders, lessors, insurers, or other persons or entities who may have a legal or financial interest in a building.

Some of the present embodiments provide a method of automatically identifying buildings that may include any exterior elevated elements. Some of these embodiments may use satellite images that are either publicly available through such services as, for example, and without limitations, Google Maps, Apple Maps, etc., or satellite images that may be purchased or licensed through third party providers.

The satellite images may then be analyzed by image processing software that is executed by processors of one or more servers to identify building features that may be indicative of elevated elements. The list of such buildings may then be provided to any interested party that may need a list of such buildings for building code enforcement, advertisement, etc.

In addition to, or in lieu of using satellite images, some embodiments may provide tabulated data available from government agencies and third parties that lists different attributes of buildings in a geographical region. Examples of the building attributes that may be provided in this type of tabulated data may include, for example, and without limitations, name of the owner(s), the owner type (e.g., individual, trust, etc.), the owner(s) contact information, owners vesting rights (e.g., joint tenant, revocable trust, trust, survivor, family trust, community property, etc.), the situs direction (e.g., north, south, east, or west), the property's address, the property's legal description (e.g., lot and track number), the property's census tract and block number, the property's latitude and longitude address, the land and the building areas, the year built, the data of the issuance of the certificate of opponency, number of bedrooms, number of bathrooms, parking area, parking type (e.g., covered or open), construction type (e.g., wood frame, metal frame, etc.), patio type, porch type, foundation type, room type, number of floors, flood zone code, name and address of the homeowner association (if any), etc.

The processor(s) of the server(s), in some embodiments analyze the tabulated data to identify buildings that may or may not require inspection. For example, some embodiments may determine that a building is not wood frame or otherwise does not have a wood structure that may need inspection. Some states or municipalities may not require inspection for single story buildings, or for structures such as a balcony, that may be less than a threshold distance from ground.

In addition to, or in lieu, of the tabulated data, some embodiments may allow user entered data (e.g., entered by an owner, an inspector, a property manager, etc.) to be used to determine whether or not a building may include exterior elevated elements and/or whether or not the exterior elevated elements may require inspection.

The processor(s) may use one or more criteria such as the age of a building, the certificate of occupancy date of the building, the frame type, the number of the stories, the geographical zone, etc., to determine whether or not a building may require inspection for exterior elevated elements. The processor(s), in some embodiments, may also provide an initial cost and duration for the inspection.

Once a building that requires inspection is identified and authorization for the inspection is received, some embodiments may drill a hole (e.g., by a bi-metal hole saw, a drill, and/or a hammer) in a small area of an exterior elevated element that requires inspection. The hole may be wide enough to allow a snake camera (also referred to as a snake endoscope camera, a borescope camera, or a snake inspection camera) or a crawler robot that includes a camera to pass through the hole. The snake camera, in some embodiments, may be a miniaturized device for minimized impact on the exterior elevated element.

The camera of the snake camera or the camera of the crawler robot may then be used to take still images and/or videos images. The still images and/or the video images are referred to herein as images for brevity. The images may be stored in a computer readable medium associated with the snake camera or the crawler robot, may be livestreamed, and/or may be transmitted to a remote location for storage and analysis.

The processor(s) may determine the existence of wood rot or other damages by identifying contrasted areas in the images. Some embodiments may use different artificial intelligent (AI) or machine learning (ML) learning tech-

niques, such as, for example, and without limitations, deep learning, to identify wood rot or other damages.

In some embodiments, the AI or ML may use a model that may be trained by data specific to the images taken by cameras from exterior elevated element that may or may not have wood rot or other specific health conditions. In addition to, or in lieu of, an automatic method, some embodiments, may allow humans to inspect the images either during a livestream play or by inspecting the recorded images. Once an issue such as wood rot or other damages is identified in an exterior elevated element, the processor(s) in some embodiments, may provide a cost and duration for repairs.

Some embodiments may include other sensors, such as, for example, and without limitations, humidity sensors, moisture sensors, etc., to collect additional data from the hole. The additional data may be used, in addition to, or in lieu of the images, to determine whether dry rot and other damages may exist in the exterior elevated element.

Some embodiments may close the hole with a cap (e.g., rubber, plastic, silicone, etc.) to prevent moisture to get into the hole. Some embodiments may install one or fans inside the hole to keep the hole dry. The fans, in some embodiments may be controlled by one or more processors. The processor(s) that control a fan may be an integrated part of the fan (e.g., inside the fan), in a control hub used to just control the same fan, may be in a control hub located in the same building and may control one or more other fans, or may be located at a remote location controlling fans in many buildings. The hub may be connected to the fan wirelessly or by wires.

Sensors, such as, for example, and without limitations, humidity sensors, moisture sensors, temperature sensors, etc., may be installed inside the hole to monitor humidity, moisture, temperature, etc., inside the hole. The sensor(s) may be integrated part(s) of the fan (e.g., may be installed on the outside or in a cavity on the fan's frame) or may be separate from the fan. The fans may be powered by alternative current (AC) from the building and/or by one or more batteries. The batteries, in some embodiments, may be replaceable and/or rechargeable.

In order to conserve energy and reduce wear and tear in a fan, some embodiments may use sensor data, such as humidity, moisture, or temperature in order to start or stop the fan. For example, the fan's processor and/or the hub may turn on the fan only when the humidity, moisture, and/or temperature inside the hole is above a threshold.

Some embodiments may install one or more ventilation windows in the exterior elevated element to circulate air to prevent dry rot of the wood in the interior of the exterior elevated element. The ventilation window, in some embodiments, may have a railing and bearing that may allow the window to be fixed to joists that with different distances from each other.

The remaining detailed description describes the present embodiments with reference to the drawings. In the drawings, reference numbers label elements of the present embodiments. These reference numbers are reproduced below in connection with the discussion of the corresponding drawing features.

FIGS. 1A-1B are functional diagrams illustrating an example embodiment of a system for inspecting and maintaining exterior elevated elements of building structures, according to various aspects of the present disclosure. With reference to FIGS. 1A-1B, the building structures **105** may include one or more exterior elevated elements **125**.

Examples of the exterior elevated elements **125** include, balconies, decks, porches, stairways, walkways, landings, etc.

FIG. 2 shows different components of an exemplary exterior elevated element of a building structure, according to prior art. With reference to FIG. 2, the exterior elevated element **200** in the example of FIG. 2 may be a balcony. As shown, the balcony **200** may include several joists **210**, several beams **215**, several decking lumbers **220**, several support posts **225**, several rail posts **230**, several blockings **235**, several balusters **240**, several handrails **245**, several ledgers **250**, a fascia **255**, an underside **260**, etc.

In order to show the interior of the balcony **200**, only portions of the decking lumbers **220** and the fascia **250** are shown in FIG. 2. The joists **210**, the beams **215**, the decking lumbers **220**, the support posts **225**, the rail posts **230**, the blockings **235**, the balusters **240**, the handrails **245**, the ledgers **250**, the fascia **255**, and underside **260** may be, at least partially, made of wood. Different wooden components of the balcony **200** may be connected to each other or to the property wall **295** by metallic parts, such as bolts, **280**, brackets, **285**, nails **290**, etc. For clarity, only some of the components of the balcony **200** are labeled in the figure.

The balcony **200** may include a covering over the decking lumbers **230** to facilitate walking over the balcony. The balcony **200** may include water proofing insulation to prevent water (e.g., rainwater) from seeping inside the balcony through any space around the decking lumbers **230**, the fascia **255**, the underside **260**, and the property wall **295**. The space delimited by the decking lumbers **220**, the fascia **255**, the underside **260**, and the property wall **295** is referred to herein as the interior space (or the interior) **205** of the balcony **200**.

It should be noted that, depending on the size and design of a balcony, the number and the arrangement of the components of a balcony may be different than the balcony **200**. For example, in the balcony **200**, the beams **215** are shown outside of the interior space **205** of the balcony **200** while other balconies may include one or more beams inside the interior space. Other types of exterior elevated elements of a building may include similar and/or different wooden or metallic components as the balcony **200**.

The interior space **205** of exterior elevated elements is an enclosed area with little to no air circulation. For wood frame structures, joists, ledgers, beams, blocking, and posts inside the interior space of the exterior elevated elements may deteriorate due to wood rot. Wood rot (also referred to as dry rot) is a condition that is caused by wood being exposed to water and moisture. Damp wood creates an ideal condition for fungal growth that weakens and decays the wood structure. In addition, a damp environment may result in metallic components, such as, nails, nuts, bolts, and brackets that are used to attach pieces of wood together to rust.

Inspection of the exterior elevated elements may be required by different state and municipal governments and/or may be requested by homeowner associations, owners, buyers, lenders, lessors, insurers, or other persons or entities who may have a legal or financial interest in a building.

The traditional eye inspection of the exterior elevated elements of a building may not reveal the health condition of the beams, joist, bridging, ledgers, bolts, nails, etc., that are inside the interior space of these elevated elements. The eye inspection of the interior spaces of these exterior elements may require demolishing portions of these structures that are large enough to allow eye inspection.

Referring back reference to FIG. 1A, some embodiments may drill a hole and may use custom-made snake cameras **150** and/or custom-made crawler robots **160** to inspect interiors of the exterior elevated elements **125**. For example, some embodiments may use a drill with a hole saw (or hole cutter) blade to drill a hole into the interior of the exterior elevated elements **125** of a building **105**. The size of the hole may be made wide enough to allow a snake camera **150** or a crawler robot **160** to pass through the hole and reach the interior space of the exterior elevated element. The hole is typically made through the underside (e.g., the underside **260** of FIG. 2) of the exterior elevated elements to prevent damage to the waterproofing material over the top (e.g., the decking lumbers **220** of FIG. 2) of the exterior elevated elements.

FIG. 3 is a perspective view of a hole saw, according to prior art. With reference to FIG. 3, the hole saw **300** may have a cylindrical shape whose annular rotation may create a hole into the interior space of an exterior elevated element. The hole saw **300** may be installed on a drill by the fastener **340** and the arbor **350**. The hole saw **300** may include several blades **320** with metallic (e.g., carbide) tips **325**.

The optional pilot drill bit **380** may be used to make a pilot hole in the material to reduce walking. The hole saw blades may be bimetal, where the edges of the blades may be made of a hardened metal (e.g., high-speed steel (HSS)) to allow the edges to stay sharp while the rest of the body of the blades may be made of a flexible metal to allow the blade to flex. The hole saw **300** may include a variable tooth pitch for fast and smooth cutting. The hole saw **300** may include chip holes (or gullets) **360** for easy removal of wood plug from inside the hole saw **300**. An example of a hole saw may be the Hole Dozer hole saw.

Referring back to FIG. 1A, instead of a hole saw, other types of drills and blades, for example, hammer drills, may be used to make the hole into the interior of the exterior elevated elements **125** in some embodiments. Once the hole is made, a custom-made snake camera (also referred to as a snake endoscope camera, a borescope camera, or a snake inspection camera) **150** or a crawler robot **160** may be used to inspect the interior of the exterior elevated element **125**.

FIG. 4A is a schematic front view of a custom-made snake camera and the associated controller, according to different aspects of the present disclosure. FIG. 4B is a functional block diagram of the components of the custom-made snake camera of FIG. 4A, according to different aspects of the present disclosure. With reference to FIGS. 4A-4B, the snake camera **150** may include a camera **410** with one or more lenses, one or more light sources **420**, and a controller **152**. The camera **410** and the light sources **420** may be mounted at the end of a flexible tube **450**. The camera **410** may capture video images and/or still images. The snake camera may be a miniaturized device to minimize the impact on the exterior elevated element.

Some of the snake cameras of the present embodiments may include one or more environmental sensors **155**. The environmental sensors **155** may measure the environmental conditions of the interior space of an exterior elevated element. The environmental sensors **155** may include, for example, and without limitations, a humidity sensor, a moisture sensor, and/or a temperature sensor. Different components of the snake camera may be connected to each other by several wires **485**, a portion of which may run through the flexible tube **450**.

As wood rot is caused in a moist environment, the environmental sensors **155** of the present embodiments provide the technical advantage of determining whether the

interior space of an exterior elevated element is suitable for the growth of dry rot causing fungi. In some embodiments, the sensors' measured parameters may be used (e.g., by the server(s) **110** of FIGS. 1A-1B) to determine whether the humidity or moisture within the interior space of an exterior elevated element is above a threshold that may promote the growth of the dry rot causing fungi. As described further below, some embodiments may install one or more fans and/or one or more ventilation windows to circulate the air between the interior space and outside of the exterior elevated elements of buildings to reduce the humidity and moisture to prevent dry rot.

With further reference to FIGS. 4A-4B, the controller **152** may be a hand-held controller. The controller **152** may include one or more processors **405**, one or more computer readable media **425**, one or more wireless (e.g., and without limitations, Wi-Fi or Bluetooth) transceivers **440**, one or more batteries **435**, one or more input devices **490**, and/or one or more output device(s) **495**. The processor(s) **405** may control the operations of the camera **410** and the light source(s) **420** through the on-off switch **455**, the light source brightness control **460**, the zoom-in control **470**, and/or the zoom-out control **475**.

The battery (or batteries) **435** may be rechargeable and/or replaceable and may provide power to different components of the controller **152** and the snake camera **150** through one or more wires **480**. The wireless transceivers **440** may provide wireless connectivity with one or more external electronic devices.

The input device(s) **490** may include the brightness control **460**, the zoom-in control **470**, and the zoom-out control **475**. The output device(s) **495** may include one or more light-emitting diodes (LEDs) to show on-off or other status.

Referring back to FIG. 1A, the controller **152** of the snake camera **150** may be configured to wirelessly communicate to a client device **153**, for example, through an application program (app) that may be downloaded into the client device **153**. The processor(s) **405** (FIG. 4B) may receive images (e.g., video images and/or still images) captured by the camera **410** and may send the images to the client device **153** (FIG. 1A). The processor(s) **405** (FIG. 4B) may receive environmental parameters, such as humidity, moisture, and temperature, measured by the environmental sensor(s) **155** and may send the parameters to the client device **153**.

In addition to, or in lieu of, the controls **460-475**, the app on the client device **153** may provide options to zoom-in and zoom-out the camera **410** (FIG. 4) and/or to adjust the brightness of the light source(s) **420**. The client device **153** app may allow the video captured by the camera **410** to be viewed on a display of the client device **153**, to be stored in the computer readable media of the client device **153**, and/or to be transmitted to external electronic devices, such as the server(s) **110**, through one or more networks **190**. The network(s) **190** may be one or more of the Internet, intranets, cellular networks, networks of servers/backend devices, and/or users' networks (e.g., Wi-Fi, Ethernet, etc.).

FIG. 5A is a schematic front view of a custom-made crawler robot and the associated controller, according to different aspects of the present disclosure. FIG. 5B is a functional block diagram of the components of custom-made crawler robot of FIG. 5A, according to different aspects of the present disclosure. With reference to FIGS. 5A-5B, the crawler robot **160** may include a camera **510** with one or more lenses, one or more light sources **520**, one or more motors **570**, several wheels **515**, and a controller **162**. The camera **5310** may capture video images and/or still images.

Some of the crawler robots of the present embodiments may include one or more environmental sensors **155**, which may be similar to the environmental sensors **155** of FIGS. **1A-1B** and **4A-4B**. The environmental sensors **155** of the present embodiments provide the technical advantage of determining whether the interior space of an exterior elevated element is suitable for the growth of dry rot causing fungi. In some embodiments, the sensors' measured parameters may be used (e.g., by the server(s) **110** of FIGS. **1A-1B**) to determine whether the humidity or moisture within the interior space of an exterior elevated element is above a threshold that may promote the growth of the dry rot causing fungi.

With further reference to FIGS. **5A-4B**, the controller **162** may be a computing device with a display **572**, a keyboard **575**, and an on-off switch **555**. The controller **162** may include one or more processor **505**, one or more computer readable media **525**, one or more wireless transceivers **540**, a power source **535**, one or more input devices **590**, and/or one or more output devices **595**. The controller **162**, in some embodiments, may include a video processor **505** to, at least partially, process images captured by the camera **510**. The processor(s) **505** may control the operations of the camera **510** (e.g., capture images, zoom-in, or zoom-out) and the light source(s) **520** (e.g., increase or decrease brightness) through the on-off switch **555**, the keyboard **575**, and the display **570**.

The processor(s) **505** may control the movements of the crawler robot **160** through the motor(s) **570**. The processor(s) **505** may receive commands through the display **572** (e.g., when the display is a touchscreen) and/or the keyboard **575** to move and steer the crawler robot inside the interior space of an exterior elevated element of a building. The processor(s) **505** may send one or more signals to the motor(s) **570** to rotate the wheels **515** and/or to turn the wheels **515** left or right.

The controller **162** may include a power source **535** that may provide power to different components of the controller **162** and the crawler robot **160** through one or more wires **580**. The power source **535** may include a power adapter that may connect to an alternative current (AC) outlet. In addition to, or in lieu of the power adapter, the power source **535** may include one or more batteries that may be rechargeable and/or replaceable.

The controller **162** may include one or more wireless (e.g., and without limitations, Wi-Fi or Bluetooth) transceivers **540** to provide wireless connectivity with an external electronic device. In addition to, or in lieu of the wireless transceivers **540**, the controller **162** may include wired connectivity through the network(s) **190** (FIGS. **1A-1B**) with one or more external devices. Different components of the crawler robot **160** and/or the controller **162** may be connected to each other by several wires **585**.

The input device(s) **590** may include the keyboard **575**. The output device(s) **595** may include the display **570**. In some embodiments, the display **570** may be a touchscreen display and may function as both an input and an output device.

Some embodiments may provide a user interface (e.g., through the display of the client device **153** or the display of the controller **162**) to monitor the images captured by the camera of the snake camera **150** or the camera of the crawler robot **160**, respectively. The images may be monitored live and/or may be recorded and stored for review at a later time. The captured images, in some embodiments, may be sent to one or more external electronic devices, such as, the client devices **120** and/or the server(s) **110** for live monitoring

and/or reviewing at a later time. The client devices **120** and **153** may be smartphones, tablets, laptop computers, desktop computers, etc.

In addition to, or in lieu of monitoring by a human, some embodiments may analyze the images captured by the cameras by electronic devices, such as the server(s) **110**, the controller **162**, and/or the client device **153** to determine the existence of dry rot in the interior space of exterior elevated elements **125** of a building and/or to determine rust in the metallic components (e.g., nuts, bolts, brackets, nails, etc.) in the interior space of exterior elevated elements **125**.

For example, the areas of wood that are damaged by dry rot may have a different color and/or a different color intensity. Color intensity, also called chroma or saturation, is a measure of the brightness or dullness of a color. The areas of wood that are damaged by dry rot may become browner or darker than the undamaged wood. The surface areas of wood that are damaged by dry rot may break into cubical like cracking or checking. The color differences among different areas of the wood, the color intensity differences among different areas of the wood, and/or the shape and size of any cracks on the wood surface may be used to determine whether the wood is damaged by dry rot.

Some embodiments may use AI to analyze the images captured from the interior spaces of the exterior elevated elements of buildings to determine the existence and/or the extent of wood rot damage. The AI model may be trained by images of healthy wood and wood that is damaged by the dry rot. The AI model may be trained to detect the color differences, the color intensity differences, and/or the differences between the shape and size (e.g., length and width) of any cracks on the healthy wood surface and the wood surface damaged by the dry rot.

The metallic components, such as nuts, bolts, brackets, nail, etc., may rust due to moisture. The rusted metal may have a different color and/or different color intensity than the metal that is not rusted. The AI model, in some embodiments, may be trained to detect the existence of rust in the metallic components using the color differences and/or color intensity differences between the rusty and healthy metallic components.

In some embodiments, for example, when the exterior elevated element is a balcony, the images captured from the interior spaces of the exterior elevated elements may be analyzed to determine the slope of the balcony surface. When the slope of the balcony is more than a threshold, the balcony may be a deficient balcony with slanted slope that may require repair.

After detecting the existence of dry rot in the captured images, further analysis may be done by the AI model to determine the extent of the wood damage and to determine a structural integrity rating. The results of the analysis may be stored and/or sent to one or more of the client devices **120**.

Some embodiments may provide an estimate of the labor amount and material required to repair the wood damage based, at least partially, on the extent of (e.g., the total area affected by) the wood rot damage and/or the type of the exterior elevated element damaged by wood rot. The estimate may be provided to one or more of the client devices **120**.

With reference to FIG. **1B**, some embodiments may install one or more environmental sensors **155**, such as moisture sensors, humidity sensors, and/or temperature sensors inside the interior space of the exterior elevated elements **125** of the buildings **105** to monitor the moisture, humidity, and/or temperature inside the interior space. The environmental

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sensors **155** may be communicatively coupled (e.g., by wires) to the controllers **150**. One controller **150** may be communicatively coupled to one or more environmental sensors **155**. The controller **150** may receive measurements of the environmental parameters, such as, moisture, humidity, temperature, etc., from the environmental sensors **155** and may send the environmental parameters wirelessly or through wires to a hub **170**.

Each hub **170** may be installed inside or on the exterior of a building **105**. Each hub **107** may receive environmental parameters from one or more controllers **155**. A hub **170** may locally store the environmental parameters, may analyze the environmental parameters, and/or may send the environmental parameters and/or the analysis results through the network(s) **190** to one or more external electronic devices such as the client devices **120** and/or the server(s) **110**.

The processor(s) of the hubs **170**, the server(s) **110**, and/or the client devices **120** may analyze the environmental parameters by comparing the value of the environmental parameters, such as, humidity, moisture, and/or temperature, with the corresponding thresholds to determine whether the environment in the interior space of the exterior elevated elements **125** may be suitable for dry rot growth. The processor(s) of the hubs **170**, the server(s) **110**, and/or the client devices **120** may generate a warning if the environmental parameters exceed the corresponding threshold for a threshold time period (e.g., several hours, several days, etc.).

Some embodiments may install one or more fans (e.g., on the underside **260** (FIG. 2) of the exterior elevated elements of a building) to circulate air between the interior and the outside of the exterior elevated elements. The number and power of the fans, in some embodiments, may be determined (e.g., by a processor of a server **110**) based on the size of the interior space and/or whether the joists **210** (FIG. 2) may divide the interior space of an exterior elevated element into several separate compartments (or joist areas), the environmental parameter measurements received from the environmental sensors, and/or the average humidity, moisture, and/or temperature of the geographical area where the property is located.

In addition to, or in lieu of, installing the fans, some embodiments may install one or more ventilation windows **175**. The number and the size of the ventilation windows may be determined (e.g., by a processor of a server **110**) based on the size of the interior space and/or whether the joists **210** (FIG. 2) may divide the interior space of an exterior elevated element into several separate compartments (or joist areas), the environmental parameter measurements received from the environmental sensors, and/or the average humidity, moisture, and/or temperature of the geographical area where the property is located.

Some embodiments may provide ventilation windows that includes movable brackets to facilitate attaching the ventilation windows to the joists **210** (FIG. 2) of an exterior elevated element of a building. FIG. 6A is a bottom view and FIG. 6B is a top view of a ventilation window **600** that may be installed on the underside of an exterior elevated element of a building, according to various aspects of the present embodiments. The ventilation window **600** may be one of the ventilation windows **175** of FIG. 1B.

FIG. 6A shows the visible side of the ventilation window **600** that faces down when it is installed on the underside of the exterior elevated element. FIG. 6B shows the side of the ventilation window **600** that faces the interior of the exterior elevated element.

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With reference to FIG. 6A, the ventilation window **600** may include a frame **605**, several ventilation openings **610**, and a hinge **615**. In the depicted embodiment, the ventilation openings **610** span across the length of the ventilation window **600**. In some embodiments, the ventilation openings **610** may span across the width of the ventilation window **600**. In some embodiments, the ventilation openings **610** may include many small opening resembling a net.

The ventilation window **600**, in some embodiments, may be ember and fire stopping. For example, the ventilation window **600**, in some embodiments, may include a mesh structure behind the ventilation openings **610** to prevent the passage of ember and fire flames through the ventilation openings **620**. The hinge **615** may facilitate opening of the ventilation window **600** and inspecting the interior space of the exterior elevated elements.

With reference to FIG. 6B, the frame **605** may include several pairs of railings **621-624**. The depicted embodiment includes four pairs of railings **621-624**. Other embodiments may include only two pairs of railings, for example either the two pairs of railing **621** and **622** or the two pairs of railing **623** and **624**.

FIG. 7 illustrates a portion of a pair of railings of FIG. 6B, according to various aspects of the present disclosure. With reference to FIG. 7, the railings may be, for example, the railings **622** of FIG. 6B. As shown, several pairs of ball bearings **721-722** and **731-732** (only two pairs are shown in FIG. 7 for brevity) may move across the railings **622**. Each pair of ball bearings **721-722** and **731-732** may be connected to each other by a corresponding rod **720** and **730**. It should be noted that when the ball bearing pairs **721-722** or **731-732** rotate, the corresponding rods **720** and **730**, which are fixed to the center of the ball bearing pairs do not rotate.

As shown, each rod **720** and **730** is connected to a corresponding bracket **725** and **735**. The brackets may be, for example, metallic plates. Each bracket **725** and **735** may include one or more holes **740**. In operation, when the ventilation window **600** (FIGS. 6A-6B) is installed on the underside of an exterior elevated element, the pair of ball bearings (e.g., the pair of ball bearings **721-722**) may be moved across the railings **622** until the corresponding bracket **725** is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for other ball bearing pairs by moving a ball bearing pair across the railings **622** until the corresponding bracket is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for ball bearing pairs on other railings (e.g., the railing **621** of FIG. 6B) until the ventilation window is securely attached at several places to one or more joists. It should be noted that the number and location of the holes on the brackets of FIGS. 7, 9, 12, 13, and 15 may be different in different embodiments.

In some embodiments, pairs of ball bearings may be inserted into (or removed from) the railings **612-624** through the gaps **650**. therefore, as many pairs of ball bearings that are needed may be inserted into the railings based on the spacing between the joists, the weight of the ventilation window, etc. In the depicted embodiment, the brackets **725** and **735** are attached to the rods **720** and **730** such that the surface of the brackets are parallel to the surface of the ball bearings **721-722** and **731-732**. In other embodiments, the brackets **725** and **735** may be attached to the rods **720** and **730** such that the surface of the brackets are perpendicular to the surface of the ball bearings **721-722** and **731-732** (e.g., facing to the right or to the left, in the depicted orientation of FIG. 7). Some embodiments may provide two different

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groups of ball bearings and brackets, in one group, the surface of the brackets may be parallel to the surface of the ball bearings and in other group the surface of the brackets may be perpendicular to the surface of the ball bearings. an end user may then select the proper group of ball bearings and brackets for a particular installation job, depending on the desired orientation of the installed ventilation window and the orientation of the joists in the interior space of the exterior elevated elements.

FIG. 8 is a bottom view of an alternative ventilation window 800 that may be installed on the underside of an exterior elevated element of a building, according to various aspects of the present embodiments. The top view of the ventilation window 800 may be similar to the top view of the ventilation window 600 of FIG. 6A. The ventilation window 800 may be one of the ventilation windows 175 of FIG. 1B.

With reference to FIG. 8, the ventilation window 800 may include several ventilation openings 610, a hinge 615, and several gaps 650, which may be similar to the corresponding components of ventilation window 600 of FIGS. 6A-6B. The ventilation window 800 may include a frame 805. The frame 805 may include several railings 821-824. The depicted embodiment includes four railings 821-824. Other embodiments may include only two railings, for example either the two railings 821 and 822 or the two railings 823 and 824.

FIG. 9 illustrates a portion of a railing of FIG. 8, according to various aspects of the present disclosure. With reference to FIG. 9, the railing may be, for example, the railing 822 of FIG. 8. As shown, several ball bearings 921 and 931 (only two ball bearings are shown in FIG. 9 for brevity) may move across the railing 822. Each ball bearing 921 and 931 may be connected to a corresponding rod 920 and 930, respectively. It should be noted that when the ball bearing 921 or 931 rotate, the corresponding rods 920 and 930, which are fixed to the center of the ball bearing do not rotate.

As shown, each rod 920 and 930 is connected to a corresponding bracket 925 and 935. The brackets may be, for example, metallic plates. Each bracket 925 and 935 may include one or more holes 940. In operation, when the ventilation window 800 (FIG. 8) is installed on the underside of an exterior elevated element, the ball bearings (e.g., the ball bearing 721) may be moved across the railing 822 until the corresponding bracket 925 is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for other ball bearing by moving a ball bearings across the railings 822 until the corresponding bracket is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for ball bearings on other railings (e.g., the railing 821 of FIG. 8) until the ventilation window is securely attached at several places to one or more joists.

In the depicted embodiment, the brackets 925 and 935 are attached to the rods 920-930 such that the surface of the brackets are parallel to the surface of the ball bearings 921-924. In other embodiments, the brackets 925 and 935 may be attached to the rods 920 and 930 such that the surface of the brackets are perpendicular to the surface of the ball bearings 921 and 931 (e.g., facing to the right or to the left, in the depicted orientation of FIG. 9). Some embodiments may provide two different groups of ball bearings and brackets, in one group, the surface of the brackets may be parallel to the surface of the ball bearings and in other group the surface of the brackets may be perpendicular to the surface of the ball bearings. An end user may then select the proper group of ball bearings and brackets for a particular

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installation job, depending on the desired orientation of the installed ventilation window and the orientation of the joists in the interior space of the exterior elevated elements.

FIG. 10 illustrates a portion of a railing of FIG. 8, according to various aspects of the present disclosure. With reference to FIG. 10, the railing 822, the ball bearings 921 and 931, and the rods 920 and 930 may be similar to the corresponding components of FIG. 9. The embodiment of FIG. 10 may include hooks 1025 and 1035 instead of the brackets 925 and 935 of FIG. 9. The hooks may be used to attach the ventilation window 800 (FIG. 8) to the joists of an exterior elevated element of a building.

It should be noted that the orientation of the hooks 1025 and 1035 with respect to the surface of the brackets may be different in different embodiments. In addition, some embodiments may provide different groups of ball bearings and hooks with different orientation for the hooks to allow an end user to select the proper ball bearings and hooks for a particular installation job, depending on the desired orientation of the installed ventilation window and the orientation of the joists in the interior space of the exterior elevated elements.

FIG. 11 is a bottom view of an alternative ventilation window 1100 that may be installed on the underside of an exterior elevated element of a building, according to various aspects of the present embodiments. The top view of the ventilation window 1100 may be similar to the top view of the ventilation window 600 of FIG. 6A. The ventilation window 1100 may be one of the ventilation windows 175 of FIG. 1B.

With reference to FIG. 11, the ventilation window 1100 may include several ventilation openings 610, a hinge 615, and several gaps 650, which may be similar to the corresponding components of ventilation window 600 of FIGS. 6A-6B. The ventilation window 1100 may include a frame 1105. The frame 1105 may include several shafts 1121-1124. The depicted embodiment includes four shafts 1121-1124. Other embodiments may include only two shafts, for example either the two shafts 1121 and 1122 or the two shafts 1123 and 1124.

FIG. 12 illustrates a portion of a shaft of FIG. 11, according to various aspects of the present disclosure. With reference to FIG. 11, the shaft may be, for example, the shaft 1121 of FIG. 11. As shown, several clips 1221 and 1231 (only two clips are shown in FIG. 12 for brevity) may move across the shaft 1121. A clip may be detached from the shaft by applying a force to the two lips 1270 to move the lips apart. A clip may be attached to the shaft by placing the lips 1270 against the shaft and applying pressure to force the lips to move away from each other and hold the clip around the shaft. Each clip 1221 and 1231 may be connected to a corresponding bracket 1225 and 1235, respectively. The clips may be, for example, and without limitations, D-clips.

The brackets may be, for example, metallic plates. Each bracket 1225 and 1235 may include one or more holes 1240. In operation, when the ventilation window 1100 (FIG. 11) is installed on the underside of an exterior elevated element, the clips (e.g., the clip 1221) may be moved across the shaft 1121 until the corresponding bracket 1225 is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for other clips by moving a clip across the shaft 1121 until the corresponding bracket is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for clips on other shafts (e.g., the shaft 1122 of FIG. 11) until the ventilation window is securely attached at several places to one or more joists.

In the depicted embodiment, the brackets **1225** and **1235** are attached to the clips **1221** and **1231** such that the surface of the brackets are parallel to the length of the shaft **1121**. In other embodiments, the brackets **1225** and **1235** may be attached to the clips **1221** and **1231** such that the surface of the brackets are perpendicular to the length of the shaft **1121**. Some embodiments may provide two different groups of clips and brackets. In one group, the surface of the brackets may be parallel to the length of the shaft and in other group the surface of the brackets may be perpendicular to the length of the shaft. An end user may then select the proper group of clips and brackets for a particular installation job, depending on the desired orientation of the installed ventilation window and the orientation of the joists in the interior space of the exterior elevated elements.

FIG. **13** illustrates a portion of a shaft of FIG. **11**, according to various aspects of the present disclosure. With reference to FIG. **13**, the shaft **1121** may be similar to the shaft **1121** of FIG. **12**. The embodiment of FIG. **13** may include the clamps **1321** and **1331** instead of the clips **1221** and **1231** of FIG. **12**. As shown, several clamps **1321** and **1331** (only two clamps are shown in FIG. **13** for brevity) may move across the shaft **1121**. A clamp may be fastened around, or loosened from, the shaft by a screw or a bolt. Each clamp **1321** and **1331** may be connected to a corresponding bracket **1325** and **1335**, respectively.

The brackets may be, for example, metallic plates. Each bracket **1325** and **1335** may include one or more holes **1340**. In operation, when the ventilation window **1100** (FIG. **11**) is installed on the underside of an exterior elevated element, the clamps (e.g., the clamp **1321**) may be moved across the shaft **1121** until the corresponding bracket **1325** is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for other clamps by moving a clamp across the shaft **1121** until the corresponding bracket is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for clamps on other shafts (e.g., the shaft **1122** of FIG. **11**) until the ventilation window is securely attached at several places to one or more joists.

In the depicted embodiment, the brackets **1325** and **1335** are attached to the clamps **1321** and **1331** such that the surface of the brackets are parallel to the length of the shaft **1121**. In other embodiments, the brackets **1325** and **1335** may be attached to the clamps **1321** and **1331** such that the surface of the brackets are perpendicular to the length of the shaft **1121**. Some embodiments may provide two different groups of clamps and brackets. In one group, the surface of the brackets may be parallel to the length of the shaft and in other group the surface of the brackets may be perpendicular to the length of the shaft. An end user may then select the proper group of clamps and brackets for a particular installation job, depending on the desired orientation of the installed ventilation window and the orientation of the joists in the interior space of the exterior elevated elements. The clamps may be placed around the shaft, for example, through the gaps **650** (FIG. **11**).

FIG. **14** is a bottom view of an alternative ventilation window **1400** that may be installed on the underside of an exterior elevated element of a building, according to various aspects of the present embodiments. The top view of the ventilation window **1400** may be similar to the top view of the ventilation window **600** of FIG. **6A**. The ventilation window **1400** may be one of the ventilation windows **175** of FIG. **1B**.

With reference to FIG. **14**, the ventilation window **1400** may include several ventilation openings **610**, a hinge **615**,

and several gaps **650**, which may be similar to the corresponding components of ventilation window **600** of FIGS. **6A-6B**. The ventilation window **1400** may include a frame **1405**. The frame **1405** may include several I-beams **1421-1424**. The depicted embodiment includes four I-beams **1421-1424**. Other embodiments may include only two I-beams, for example either the two I-beams **1421** and **1422** or the two I-beams **1423** and **1424**.

FIG. **15** illustrates a front view of an I-beam of FIG. **14**, according to various aspects of the present disclosure. With reference to FIG. **14**, the I-beam may be, for example, the I-beam **1421** of FIG. **14**. Several trolleys may move across the I-beam **1421** (only one I-beam **1580** is shown in the front view of FIG. **15**). The trolley **1580** may include several wheels **1531-1532** and **1541-1542**. As shown, the wheels **1531-1532** may rotate in a plane that is perpendicular to the rotation plane of the wheels **1541-1542**. The trolley **1580** may include several shafts **1541-1542** and several nuts **1560** that connect different components of the trolley **1580** together. As the wheels **1531-1532** and **1541-1542** rotate in their respective rotation plane, the trolley **1580** moves along the I-beam. It should be noted that the trolley **1580** is configured such that shafts **1541-1542** do not rotate as the trolley **1580** moves along the I-beam.

As shown, the bracket **1531** is attached to the shaft **1541**. The bracket **1521** may be similar to the brackets **725** and **735** of FIG. **7**, the brackets **925** and **935** of FIG. **9**, the brackets **1225** and **1235** of FIG. **12**, or the brackets **1325** and **1335** of FIG. **13**. The bracket **1521** may include one or more holes that are similar to the holes **740**, **940**, **1240**, or **1740** of FIGS. **7**, **9**, **12**, and **13**, respectively. The hole(s) of the bracket **1521** is/are not shown in the front view of FIG. **15**. The bracket may be, for example, metallic plates.

In operation, when the ventilation window **1400** (FIG. **14**) is installed on the underside of an exterior elevated element, the trolleys (e.g., the trolley **1580**) may be moved across the I-beam **1421** until the bracket **1521** is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for other trolleys by moving a trolley across the I-beam **1421** until the corresponding bracket is adjacent to a joist. The bracket may then be fixed to the joist by nails, bolts, screws, etc. The same operation may be repeated for trolleys on other I-beams (e.g., the I-beam **1422** of FIG. **14**) until the ventilation window is securely attached at several places to one or more joists.

In the depicted embodiment, the bracket **1521** is attached to the trolley **1580** such that the surface of the bracket is parallel to the length of the I-beam **1421**. In other embodiments, the bracket **1521** may be attached to the trolley **1580** such that the surface of the bracket is perpendicular to the length of the I-beam **1421**. Some embodiments may provide two different groups of trolleys and brackets. In one group, the surface of the brackets may be parallel to the length of the I-beam and in other group the surface of the brackets may be perpendicular to the length of the I-beam. An end user may then select the proper group of trolleys and brackets for a particular installation job, depending on the desired orientation of the installed ventilation window and the orientation of the joists in the interior space of the exterior elevated elements. The trolleys may be placed around the shaft, for example, through the gaps **650** (FIG. **14**).

Referring back to FIG. **1B**, any combination of the fans **140**, the environmental sensors **155**, and/or the ventilation windows **175** may be installed in an exterior elevated element **125**. For example, depending on the size of the interior space of the exterior elevated element, the climate in the region where the exterior elevated element is located, the

distance between the joists, and/or the number of separate compartments created by the joist in the interior space of the exterior elevated element, only one fan, multiple fans, only one environmental sensor, multiple environmental sensors, only one ventilation window, multiple ventilation windows, or any combination of one or more fans, one or more environmental sensors, or one or more ventilation windows may be installed in the exterior elevated element.

With further reference to FIG. 1B the fans 140 may start or stop based on a schedule (e.g., a period of being on and circulating the air followed by a period of being off). For example, the fans 140 may receive one or more signals from a controller 150 or from a hub 170 to turn on or off based on the schedule. In some embodiments, the fans may be controlled based on the value of the environmental parameter measurements received from the environmental sensor(s) 155.

FIG. 16 is a functional diagram illustrating a controller that controls one or more fans and/or one or more environmental sensors of an exterior elevated element of a building, according to various aspects of the present disclosure. With reference to FIG. 16, the controller 150 may be any of the controllers 150 of FIG. 1B.

The controller 150 may include one or more processors 1605, one or more computer readable media 1625, one or more network interfaces 1640, and a power source 1635. The controller 150 may be communicatively coupled (e.g., by wires or through the network interface 1640) to one or more fans 140 and/or one or more environmental sensors 155. It should be noted that, although several fans 140 and several environmental sensors are shown in FIG. 16, any number of one or more fans and/or any number of one or more environmental sensors may be controlled by a controller, such as the controller 150.

The processor(s) 1605 may receive environmental measurement parameters from the environmental sensor(s) 155. The processor(s) 1605 may store the environmental measurement parameters in the computer readable media 1625 and/or may send the environmental measurement parameters to the hub 170 through the network interface(s) 1640.

The power source 1635 may include a power adapter that may connect to an AC outlet. The network interface(s) 1640 may be one or more wireless (e.g., and without limitations, Wi-Fi or Bluetooth) transceivers to provide wireless connectivity with an external electronic device. In addition to, or in lieu of the wireless transceivers, the network interface(s) 1640 may include wired connectivity to the hub 170.

The processor(s) 1605 may control the fan(s) 140. For example, the processor(s) 1605, in some embodiments, may turn the fans 140 on or off based on a schedule. The processor(s) 1605 may send one or more signals to the fans 140 to turn on the fans 140 for a first time period. The processor(s) 1605 may send one or more signals to the fans 140 to turn off the fans 140 for a second time period or off based on the schedule. The processor(s) 1605 may repeat turning the fan(s) 140 on or off.

In some embodiments, processor(s) 1605 may control the fans 140 based on the value of the environmental parameter measurements received from the environmental sensor(s) 155. The processor(s) 1605 may compare an environmental parameter measurement with a corresponding threshold and if the environmental parameter measurement exceeds the threshold (e.g., the humidity or the moisture is more than a threshold) for a period of time (e.g., several hours, several days, etc.), the processor(s) 1605 may send one or more signals to the fan(s) 140 to turn the fan(s) 140 on. The

processor(s) 1605 may send one or more signals to the fan(s) 140 to turn the fans 140 off when the environmental parameter measurements become less than or equal to the corresponding thresholds. The processor(s) 1605 may send a message to the hub 170 whenever a fan 140 is turned on or off.

FIG. 17 is a functional diagram illustrating a hub that is used to communicate with one or more controllers associated with the exterior elevated elements of a building, according to various aspects of the present disclosure. The hub 170 may include one or more processors 1705, one or more computer readable media 1725, one or more network interfaces 1740, and a power source 1735. The hub 170 may be communicatively coupled (e.g., by wires or through the network interface(s) 1740) to one or more controllers 150. The controller(s) 150 may be similar to the controller 150 of FIG. 16 that may be used to control one or more environmental sensors 155 and/or one or more fans 140.

The processor(s) 1705 may receive environmental measurement parameters from the controller(s) 150. The processor(s) 1705 may store the environmental measurement parameters in the computer readable media 1725 and/or may send the environmental measurement parameters to one or more external electronic devices, such as, the client devices 120 and/or the server(s) 110 through the network(s) 190.

The power source 1735 may include a power adapter that may connect to an AC outlet. The network interface(s) 1740 may be one or more wireless (e.g., and without limitations, Wi-Fi or Bluetooth) transceivers to provide wireless connectivity with an external electronic devices (e.g., the controller(s) 150, the client devices 120 and/or the server(s) 110). In addition to, or in lieu of the wireless transceivers, the network interface(s) 1740 may include wired connectivity to the controller(s) 150.

The processor(s) 1705 may receive the status (e.g., on, off, not responding, etc.) of the fan(s) 140 (FIG. 16) from the controller(s) 150. In some embodiments, processor(s) 1705 may the control the operations of the fan(s) 140. In some of these embodiments, the processor(s) 1705 may control the fan(s) 140 through their corresponding controller(s) 150. In other embodiments, the processor(s) 1705 may directly control the fan(s) 140. In these embodiments, the controller(s) 150 do not communicate with the fan(s) 140 (e.g., the controller(s) 150 only communicate with the environmental sensor(s) 155).

For example, the processor(s) 1705, in some embodiments, may turn the fans 140 on or off based on a schedule. The processor(s) 1705 may send one or more signals to the fans 140 (either directly or through the corresponding controller(s) 150) to turn on the fans 140 for a first time period. The processor(s) 1705 may send one or more signals to the fans 140 (either directly or through the corresponding controller(s) 150) to turn off the fans 140 for a second time period or off based on the schedule. The processor(s) 1705 may repeat turning the fan(s) 140 on or off.

In some embodiments, processor(s) 1705 may control the fans 140 based on the value of the environmental parameter measurements received from the environmental sensor(s) 155. In some embodiments, the processor(s) 1705 may compare an environmental parameter measurement received from an environmental sensor with a corresponding threshold and if the environmental parameter measurement exceeds the threshold (e.g., the humidity or the moisture is more than a threshold) for a period of time (e.g., several hours, several days, etc.), the processor(s) 1705 may send one or more signals to the fan(s) 140 (either directly or through a corresponding controller 150) to turn the fans 140 on. The processor(s) 1705 may send one or more signals to

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the fan(s) 140 (either directly or through a corresponding controller 150) to turn the fan(s) 140 off when the environmental parameter measurement becomes less than or equal to the corresponding thresholds.

In some embodiments, the processor 1605 of a controller 150 and/or the processor 1705 of a hub 170 may save the current status of a fan 140 (e.g., on or off) in computer readable medium. When a fan does not respond to an on or off signal, the processor 1605 of a controller 150 and/or the processor 1705 of a hub 170 may set the status of the fan 140 to failed and may send an alert message to one or more external devices, such as the client devices 120 and/or the server(s) 110 of FIG. 1B.

FIG. 18 is a flowchart illustrating an example process 1800 for inspecting the interior space of an exterior elevated element of a building, according to various aspects of the present disclosure. The process 1800, in some of the present embodiments, may be performed during inspection of an exterior elevated element of a building.

With reference to FIG. 18, an area of a wooden exterior elevated element of a building may be identified (at block 1802) that requires inspection where there is no access to pass a camera from the outside into the interior space of the exterior elevated element. A hole may be drilled (at block 1805) into the interior space of a wooden exterior elevated element. For example, a hole may be drilled into the interior of the exterior elevated element as described above with reference to FIGS. 1A-1B and 3. A camera may be passed (at block 1810) through the hole into the interior space of the exterior elevated element. For example, a snake camera or a camera installed on a crawler robot may be passed into the interior space of the exterior elevated element as described above with reference to FIGS. 4A-4B and 5A-5B.

One or more images may be captured (at block 1815) by the camera from the interior space of the exterior elevated element. For example, the controller 152 of the snake camera 150 may send one or more signals to the camera 410 to capture video images or still images of the interior space, as described above with reference to FIGS. 4A-4B. As another example, the controller 162 of the crawler robot 160 may send one or more signals to the camera 510 to capture video images or still images of the interior space, as described above with reference to FIGS. 5A-5B. The camera, in some embodiments, may take video and/or still images. The camera may take visible light and/or infrared light images.

The captured images may then be analyzed (at block 1820) to identify one or more of color differences of the wooden surfaces, color intensity differences of the wooden surfaces, and the shape and the size of any cracks on the wooden surfaces. For example, the processor of an electronic device, such as the client device 153 (FIG. 1A), the controller 162 of the crawler robot 160, or a sever 110 may analyze the images, as described above with reference to FIG. 1A. The existence of wood rot in the interior space of the exterior elevated element may then be determined (at block 1825) based on the analysis.

In addition to, or in lieu of finding wood rot in the interior space of the exterior elevated element, analyzing the images may identify rust on the metallic surfaces of components, such as nuts, bolts, brackets, nails, in the interior space of the exterior elevated element. For example, the rusted metal may have a different color and/or different color intensity than the metal that is not rusted. The hole in some embodiments (e.g., the embodiments described below with reference to FIG. 19) may be permanently sealed. For example, and without limitations, the hole may be filled with spackle

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paste, which may be made of gypsum powder and other binders. Once the spackle paste is applied and dries, it permanently seals (or paths) the hole. In other embodiments, the hole may be covered by a ventilation window (e.g., as described above with reference to FIGS. 6A-15), or may be plugged by a cap or plug that may be, for example, made of rubber, plastic, silicone, etc. The process 1800 may then end.

In some embodiments, the process 1800 may also pass one or more environmental sensors, such as, for example, a humidity sensor, a moisture sensor, a temperature sensor, etc., through the hole after the hole is drilled. The environmental sensors may, for example, be attached to the snake camera (e.g., as shown in FIG. 4A), connected to a crawler robot (e.g., as shown in FIG. 5), etc. The environmental sensors may make measurements of parameters, such as humidity, moisture, and/or temperature, which may be used to determine whether the wood in the interior space of the balcony has dry rot and may need treatment.

FIG. 19 is a flowchart illustrating an example process 1900 for drilling a hole into the area between two interior joists of a balcony to provide access to pass a camera to inspect the area between the two joists, according to various aspects of the present disclosure. The process 1900, in some of the present embodiments, may be performed during the inspection of an existing balcony.

From the outside of a balcony, the locations of two wooden joists in the interior of the balcony may be detected (at block 1905) where there is no access to pass a camera from the outside of the balcony into the interior space of the balcony between the two wooden joists. For example, an electronic stud finder may be used in some embodiments to find the location of two joists in the interior of the balcony.

FIG. 20 shows the closed areas that may be formed between the joists in the interior of a balcony where a hole has to be drilled to pass a camera inside, according to various aspects of the present disclosure. The balcony 2000 is shown in the same perspective view as the balcony 200 of FIG. 2, except that in FIG. 2 the top of the balcony 200 is removed to show some of the inside components.

As shown in FIG. 20, several closed interior spaces, such as the closed spaces 2001-2006 may exist in the interior of the balcony 2000. For clarity, not every interior component of the balcony is shown in the figure. Depending on the location of the closed interior spaces 2001-2006, the spaces may be surrounded by several different pieces of wood, such as joists, ledgers, blockings, etc. The upper side of each closed space may be covered by decking lumbers 220 (only one decking lumber is shown for clarity), plywood, waterproofing coating, tiles, and/or paint, etc. The bottom side of each closed space may be covered, for example, by lath wire (also referred to as chicken wire) and may be covered by stucco. The spaces 2001-2006 may also include metallic components, such as bolts 280, brackets 285, nuts, nails, etc.

Referring back to FIG. 19, a hole may be drilled (at block 1910) into the interior space of the balcony between the two wooden joists. For example, as shown in FIG. 20, a temporary hole 2010 may be drilled from the outside of the balcony into the closed interior space 2004 of the balcony. The hole may be drilled, for example, by a bi-metal hole saw, a drill, and/or a hammer, etc. The hole may be made just wide enough to allow a snake camera or a crawler robot to pass through. Drilling a hole that is as small as possible to allow a snake camera or a crawler robot to pass through provides the advantage of making patching the hole easier and the place where the hole was become less visible to the eye after patching. In some embodiments, the hole may be made from the underside 260 of the balcony to prevent any

damage to the paint, tiles, waterproof coating, decking lumber, etc., that may be on the upper surface of the balcony.

A camera may be passed (at block **1915**) through the hole into the interior space of the balcony between the two wooden joists. The camera may be, for example, similar to the camera **410** that is part of a snake camera **150**, as shown in FIGS. **4A-4B**. The camera may be, for example, similar to the camera **510** installed on a crawler robot **160**, as shown in FIGS. **5A-5B**, etc. The snake camera, or the crawler robot, may include one or more environmental sensors **155**, as described above with reference to FIGS. **4A-4** and **5A-5B**.

One or more images may be captured (at block **1920**) by the camera from the wooden surfaces in the interior space of balcony that is surrounded by multiple wooden surfaces. The images may also show metallic components, such as nuts, bolts, nails, brackets, etc. The camera, in some embodiments, may take video and/or still images. The camera may take visible light and/or infrared light images.

The images taken by the camera may be analyzed (at block **1925**) to identify one or more of color differences of the wooden surfaces, color intensity differences of the wooden surfaces, and the shape and the size of any cracks on the wooden surfaces. The existence of wood rot may be determined (at block **1930**), based on the analysis, in the interior space of the balcony between the two wooden joists. In addition to, or in lieu of finding wood rot in the interior space of the exterior elevated element, analyzing the images may identify rust in the metallic components, such as nuts, bolts, brackets, nails, in the in the interior space of the exterior elevated element. For example, the rusted metal may have a different color and/or different color intensity than the metal that is not rusted.

The camera may be removed (at block **1935**) from the interior space of the balcony. The hole may be sealed (at block **1940**). The process **1900** may then end. The hole, in some embodiments, may be permanently sealed. For example, and without limitations, the hole may be filled with spackle paste, which may be made of gypsum powder and other binders. Once the spackle paste is applied and dries, it permanently seals (or paths) the hole. Permanently sealing the hole may provide the technical advantage of restoring the balcony to the original condition prior to drilling the hole and may ensure not moisture may get into the interior space of the balcony. In other embodiments, the hole may be covered by a ventilation window (e.g., as described above with reference to FIGS. **6A-15**), or may be plugged by a cap or plug that may be, for example, made of rubber, plastic, silicone, etc.

In some embodiments, the process **1900** may also pass one or more environmental sensors, such as, for example, a humidity sensor, a moisture sensor, a temperature sensor, etc., may be passed through the hole after the hole is drilled. The environmental sensors may, for example, be attached to the snake camera (e.g., as shown in FIG. **4A**), connected to a crawler robot (e.g., as shown in FIG. **5**), or etc. The environmental sensors may make measurements of parameters, such as humidity, moisture, and/or temperature, which may be used to determine whether the wood in the interior space of the balcony may need treatment.

With reference to the process **1800** of FIG. **18** and the process **1900** of FIG. **19**, the camera be an infrared camera. Some embodiments may pass two cameras through the hole into the interior space of the structure, one camera for taking infrared images and another camera for taking visual light images. For example, both cameras may be installed on the same or on a different snake camera or crawler robot. The images taken by the infrared camera provide the advantage

of detecting temperature differences on the wood surfaces, which may indicate wet areas, or areas that have dry rot. Some embodiments may combine the information collected from analyzing the visible light images, the infrared images, and/or the environmental sensor(s) readings to determine the existence of dry rot and/or excess moisture in the interior spaces of balconies and other exterior elevated elements of a building. For example, the areas that are identified by multiple methods as having dry rot may be identified as the area where there is a high confidence that are affected by dry rot.

FIG. **21** is a flowchart illustrating an example process **2100** for drilling a hole into the area between two interior joists of a balcony to provide access to pass an ultrasound probe to inspect the area between the two joists, according to various aspects of the present disclosure. The process **2100**, in some of the present embodiments, may be performed during the inspection of an existing balcony.

From the outside of a balcony, the locations of two wooden joists in the interior of the balcony may be detected (at block **2105**) where there is no access to pass an ultrasound probe from the outside of the balcony into the interior space of the balcony between the two wooden joists. For example, an electronic stud finder may be used in some embodiments to find the location of two joists in the interior of the balcony.

A hole may be drilled (at block **2110**) into the interior space of the balcony between the two wooden joists. For example, as shown in FIG. **20**, a temporary hole **2010** may be drilled from the outside of the balcony into the closed interior space **2004** of the balcony. The hole may be drilled, for example, by a bi-metal hole saw, a drill, and/or a hammer, etc. The hole may be made just wide enough to allow a small ultrasound probe that is installed on a snake cable or a crawler robot to pass through.

Drilling a hole that is as small as possible to allow the ultrasound probe over a snake cable or a crawler to pass through provides the advantage of making patching the hole easier and the place where the hole was become less visible to the eye after patching. In some embodiments, the hole may be made from the underside **260** of the balcony to prevent any damage to the paint, tiles, waterproof coating, decking lumber, etc., that may be on the upper surface of the balcony. The ultrasound probe may be passed (at block **2115**) through the hole into the interior space of the balcony between the two wooden joists.

FIG. **22A** is a schematic front view of a custom-made snake ultrasound probe and the associated controller, according to different aspects of the present disclosure. FIG. **22B** is a functional block diagram of the components of the custom-made snake ultrasound probe of FIG. **22A**, according to different aspects of the present disclosure. With reference to FIGS. **22A-22B**, the snake ultrasound probe **2250** may include an ultrasound probe **2210**, a flexible tube **2250**, and a controller **2252**. The ultrasound probe **2210** and the controller **2252** are also referred to as an ultrasound scanner. The ultrasound probe **2210** may have a small formfactor (e.g., approximately 1"×1"×5" or less). The ultrasound probe **2210** may be mounted at the end of the flexible tube **2250**. The ultrasound probe **2250** may generate ultrasound waves and may record the ultrasound waves that are reflected from different surfaces. The snake ultrasound probe **2250** may be a miniaturized device to minimize the impact for drilling a hole into the interior of the balcony.

Some of the snake ultrasound probes of the present embodiments may include one or more environmental sensors **155**. The environmental sensors **155** may measure the

environmental conditions of the interior space of an exterior elevated element, such as a balcony. The environmental sensors **155** may include, for example, and without limitations, a humidity sensor, a moisture sensor, and/or a temperature sensor, which were described above. The snake ultrasound probe **2250**, in some embodiments, may include a camera **410** and one or more light sources **420**, which may function similar to the camera **410** and light source(s) **420** of FIGS. **4A-4B**. The camera **410** and light source(s) **420** may be used to capture images of the interior of an exterior elevated element to detect wood rot on wood surfaces and rust on metallic surfaces, as described above. In addition to, or in lieu of being used for rot and rust detection, the camera **410** and light source(s) **420** may be used to provide images to allow an operator to navigate the snake ultrasound probe in the interior space of an exterior elevated element.

With further reference to FIGS. **22A-22B**, different components of the snake ultrasound probe **2250** may be connected to each other by several wires **2285**, a portion of which may run through the flexible tube **2250**. The controller **2252** may be a hand-held controller. The controller **2252** may include one or more processors **2205**, one or more computer readable media **2225**, one or more wireless (e.g., and without limitations, Wi-Fi or Bluetooth) transceivers **2240**, one or more batteries **2235**, one or more input devices **2290**, and/or one or more output device(s) **2295**. The processor(s) **2205** may control the operations of the ultrasound probe **2210** through the on-off switch **2255**, the directional movement control buttons **2270**, and/or the control buttons **2275**.

The battery (or batteries) **2235** may be rechargeable and/or replaceable and may provide power to different components of the controller **2252** and the snake ultrasound probe **2250** through one or more wires **2280**. The wireless transceivers **2240** may provide wireless connectivity with one or more external electronic devices.

The input device(s) **2290** may include directional movement control buttons **2270** (e.g., to move the direction of the ultrasound waves) and the control buttons **2275** (e.g., to focus the ultrasound beam, to save ultrasound images, to review the ultrasound images, etc.). The output device(s) **2295** may include a display and one or more light-emitting diodes (LEDs) to show on-off or other status.

The snake ultrasound probe **2250** may include a transducer **2261** for generating ultrasound waves, a pulse generator **2262** for generating a carrier pulse wave, an ultrasound transmitter **2263** for transmitting ultrasound waves, an ultrasound recorder **2264** for recording the ultrasound waves echoes, the camera **410**, the light source(s) **420**, and the environmental sensor(s) **155**.

The controller **2252** may be configured to wirelessly communicate to a client device (such as the client device **153** of FIG. **1A**), for example, through an application program (app) that may be downloaded into the client device **153**. The processor(s) **2205** (FIG. **4B**) may receive images (e.g., video images and/or still images) captured by the camera **410** and may send the images to the client device **153** (FIG. **1A**). The processor(s) **2205** may receive environmental parameters, such as humidity, moisture, and temperature, measured by the environmental sensor(s) **155** and may send the parameters to the client device **153**. The processor(s) **2205** may receive the ultrasound echo recordings from the ultrasound probe **2210** and may generate visible images from the ultrasound recordings. The processor(s) **2205** may analyze the images generated from the reflected ultrasound waves to identify wood rot on the wood surfaces and/or may display the images on a display of the controller **2252**. Some

embodiments may combine the information collected from analyzing the visible light images, the infrared images, the images generated from the reflected ultrasound waves, and/or the environmental sensor(s) readings to determine the existence of dry rot and/or excess moisture in the interior spaces of balconies and other exterior elevated elements of a building. For example, the areas that are identified by multiple methods as having dry rot may be identified as the area where there is a high confidence that are affected by dry rot.

In addition to, or in lieu of, the buttons **2270** and **2275**, the app on the client device **153** may provide similar controls. The client device **153** app may allow the images generated from the reflected ultrasound waves and/or the images taken by the camera **410** to be viewed on a display of the client device **153**, to be stored in the computer readable media of the client device **153**, and/or to be transmitted to external electronic devices, such as the server(s) **110** of FIG. **1A**, through one or more networks **190**.

FIG. **23A** is a schematic front view of a custom-made crawler robot and the associated ultrasound probe and controller, according to different aspects of the present disclosure. FIG. **23B** is a functional block diagram of the components of custom-made crawler robot of FIG. **23A**, according to different aspects of the present disclosure. With reference to FIGS. **23A-23B**, the crawler robot **2360** may include an ultrasound probe **2210**, one or more motors **2370**, several wheels **2315**, a controller **2362**, a camera **510**, and one or more light sources **520**. The ultrasound probe **2210** and the controller **2362** are referred to as an ultrasound scanner. The ultrasound probe **2210** may be similar to the ultrasound probe **2210** of FIGS. **22A-22B** and may provide similar functions. The camera **510** and light source(s) **520** may be used to capture images of the interior of an exterior elevated element to detect wood rot on wood surfaces and rust on metallic surfaces, as described above. In addition to, or in lieu of being used for rot and rust detection, the camera **510** and light source(s) **520** may be used to display images on the display **2372** to allow an operator to navigate the crawler robot **2360** in the interior space of an exterior elevated element.

Some of the crawler robots of the present embodiments may include one or more environmental sensors **155**, which may be similar to the environmental sensors **155** described above. The controller **2362** may be a computing device with a display **2372**, a keyboard **2375**, and an on-off switch **2355**. The controller **2362** may include one or more processor **2305**, one or more computer readable media **2325**, one or more wireless transceivers **2340**, a power source **2335**, one or more input devices **2390**, and/or one or more output devices **2395**. The processor(s) **2305** may control the operations of the ultrasound probe **2210** through the on-off switch **2360**, the keyboard **2375**, and the display **2370**.

The processor(s) **2305** may control the movements of the crawler robot **2360** through the motor(s) **2370**. The processor(s) **2305** may receive commands through the display **2372** (e.g., when the display is a touchscreen) and/or the keyboard **2375** to move and steer the crawler robot inside the interior space of an exterior elevated element of a building. The processor(s) **2305** may send one or more signals to the motor(s) **2370** to rotate the wheels **2315** and/or to turn the wheels **2315** left or right. The processor(s) **2305** may receive the ultrasound echo recordings from the ultrasound probe **2210** and may generate visible images from the ultrasound recordings. The processor(s) **2305** may analyze the images

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generated from the ultrasound echo recordings to identify wood rot on the wood surfaces and/or may display the images on the display 2372.

The controller 2362 may include a power source 2335 that may provide power to different components of the controller 2362 and the crawler robot 2360 through one or more wires 2380. The power source 2335 may include a power adapter that may connect to an alternative current (AC) outlet. In addition to, or in lieu of the power adapter, the power source 2335 may include one or more batteries that may be rechargeable and/or replaceable.

The controller 2362 may include one or more wireless (e.g., and without limitations, Wi-Fi or Bluetooth) transceivers 2340 to provide wireless connectivity with an external electronic device. In addition to, or in lieu of the wireless transceivers 2340, the controller 2362 may include wired connectivity through the network(s) 190 (FIGS. 1A-1B) with one or more external devices. Different components of the crawler robot 2360 and/or the controller 2362 may be connected to each other by several wires 2385

The input device(s) 2390 may include the keyboard 2375. The output device(s) 2395 may include the display 2370. In some embodiments, the display 2370 may be a touchscreen display and may function as both an input and an output device.

Referring back to FIG. 21, ultrasound waves may be generated (At block 2120) by the ultrasound probe. For example, the ultrasound probe may direct ultrasound waves towards different surface of the interior space of the balcony. The ultrasound waves reflected (or echoed) from the surfaces in the interior space of the balcony may be recorded (at block 2125) by the ultrasound probe. One or more images may be generated (at block 2130) from the reflected ultrasound waves. The images may be visible image generated from the recorded echoes. For example, the ultrasound probe 2210 of FIGS. 22A-22B and 23A-23B may direct ultrasound waves towards different surface of the interior space of the balcony and may record the reflected waves. The processor(s) 2205 of FIGS. 22A-22B or the processor(s) 2305 of FIGS. 23A-23B may generate visible images from the recorded ultrasound echoes.

The images generated from the reflected ultrasound waves may be analyzed (at block 2135) to identify luminance differences of the wooden surfaces and/or the shape and the size of any cracks on the wooden surfaces. The existence of wood rot may be determined (at block 2140), based on the analysis, in the interior space of the balcony between the two wooden joists. Using ultrasound waves to generate visible images from the ultrasound waves that are reflected from the surfaces in the interior of an exterior elevated element of a building, such as a balcony, provides the technical advantage of providing images from the surfaces that may not be in direct line of sight of a visible light, or infrared light, camera.

The ultrasound probe may be removed (at block 2145) from the interior space of the balcony. The hole may be sealed (at block 2150). The process 2100 may then end. The hole in, some embodiments, may be permanently sealed. For example, and without limitations, the hole may be filled with spackle paste, which may be made of gypsum powder and other binders. Once the spackle paste is applied and dries, it permanently seals (or paths) the hole. In other embodiments, the hole may be covered by a ventilation window (e.g., as described above with reference to FIGS. 6A-15), or may be plugged by a cap or plug that may be, for example, made of rubber, plastic, silicone, etc.

In some embodiments, the process 2100 may also pass one or more environmental sensors, such as, for example, a

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humidity sensor, a moisture sensor, a temperature sensor, etc., may be passed through the hole after the hole is drilled. The environmental sensors may, for example, be attached to the snake camera (e.g., as shown in FIG. 4A), connected to a crawler robot (e.g., as shown in FIG. 5), or etc. The environmental sensors may make measurements of parameters, such as humidity, moisture, and/or temperature, which may be used to determine whether the wood in the interior space of the balcony may need treatment.

FIG. 24 is a flowchart illustrating an example process 2400 for installing a fan in the interior space of an exterior elevated element of a building and operating the fan based on parameters measured by an environmental sensor, according to various aspects of the present disclosure. The process 2400, in some of the present embodiments, may be performed for monitoring and maintaining the interior space of the exterior elevated element.

With reference to FIG. 24, a hole may be drilled (at block 2405) from the outside of an exterior elevated element into the interior space of the exterior elevated element. For example, a hole may be drilled into the interior of the exterior elevated element as described above with reference to FIGS. 1B and 3. An environmental sensor may be installed (at block 2410), through the hole, in the interior space of the exterior elevated element. The environmental sensor may be, for example, a humidity sensor, a moisture sensor, or a temperature sensor.

The environmental sensor may be connected by a plurality of wires to a controller that includes a processor and a network interface. For example, the environmental sensor 155 may be connected to a controller 150 that includes a processor 1605 and a network interface 1640, as described above with reference to FIG. 16. The network interface may be, for example, a wireless transceiver or a network interface card.

An air circulating fan may be installed (at block 2415) to circulate air between the interior of the exterior elevated element of the building and the outside of the exterior elevated element. For example, an air circulating fan 140 may be installed to circulate air between the interior of the exterior elevated element of the building and the outside of the exterior elevated element, as described above with reference to FIGS. 1B and 16.

Blocks 2420-2435 of the process 2400 of be performed by the processor 1605 (FIG. 16) of the controller 150 or by the processor 1705 (FIG. 17) of the hub 170. Measured parameters may be received (at block 2420) from the environmental sensor. For example, the measured parameters from the environmental sensor 155 may be received at the controller 150, as described above with reference to FIG. 16. The processor 1605 of the controller 150 may then send the measured parameters to the hub 170 through the network interface 1640.

A determination may be made (at block 2425) whether the measured parameters exceed a threshold. For example, the processor 1605 of the controller or the processor 1705 of the hub 170 may compare the measured parameters with a threshold to determine whether the measured parameters exceed the threshold for a time period. When the measured parameters exceed the threshold for the time period, one or more signals may be sent (at block 2430) to the fan to turn on the fan and circulate the air. The process 2400 may then proceed to block 2420, which was described above. When the measured parameters do not exceed the threshold for the time period, one or more signals may be sent (at block 2435)

to the fan to turn the fan off to stop circulating the air. The process **2400** may then proceed to block **2420**, which was described above.

FIG. **25** is a flowchart illustrating an example process **2500** for installing a fan in the interior space of an exterior elevated element of a building and operating the fan based on an operating schedule, according to various aspects of the present disclosure. The process **2500**, in some of the present embodiments, may be performed for monitoring and maintaining the interior space of the exterior elevated element.

With reference to FIG. **25**, a hole may be drilled (at block **2505**) from the outside of an exterior elevated element into the interior space of the exterior elevated element. For example, a hole may be drilled into the interior of the exterior elevated element as described above with reference to FIGS. **1B** and **3**.

An air circulating fan may be installed (at block **2510**) to circulate air between the interior of the exterior elevated element of the building and the outside of the exterior elevated element. For example, an air circulating fan **140** may be installed to circulate air between the interior of the exterior elevated element of the building and the outside of the exterior elevated element, as described above with reference to FIGS. **1B** and **16**.

Blocks **2515-2540** of the process **2500** of be performed by the processor **1605** (FIG. **16**) of the controller **150** or by the processor **1705** (FIG. **17**) of the hub **170**. The operating schedule of the fan may be received (at block **2515**). For example, the processor **1605** (FIG. **16**) of the controller **150** or the processor **1705** (FIG. **17**) of the hub **170** may receive the fan's operating schedule from an external electronic device, such as a client device **120** or a server **110** shown in FIG. **1B**.

The fan's operating schedule may be checked (at block **2520**) to determine whether the fan has to be turned on or off. For example, the processor **1605** of the controller or the processor **1705** of the hub **170** may periodically check the fan's operating schedule.

A determination may be made (at block **2525**) whether the fan has to be turned on based on the operating schedule. If yes, one or more signals may be sent (at block **2530**) to the fan to turn the fan on and circulate the air. For example, the processor **1605** of the controller or the processor **1705** of the hub **170** may send one or more signals to the fan to turn the fan on. The process **2500** may then proceed to block **2520**, which was described above.

When a determination is made (at block **2525**) that the fan does not have to be turned, a determination may be made (at block **2535**) whether the fan has to be turned off based on the operating schedule. If yes, one or more signals may be sent (at block **2540**) to the fan to turn the fan off to stop circulating the air. For example, the processor **1605** of the controller or the processor **1705** of the hub **170** may send one or more signals to the fan to turn the fan off. The process **2500** may then proceed to block **2520**, which was described above.

Some embodiments may identify buildings that include exterior elevated elements that may require inspection. Some of the present embodiments may provide a method of automatically identifying the buildings that may include any exterior elevated elements. Some of these embodiments may use satellite images that are either publicly available through services such as, for example, and without limitations, Google Maps, Apple Maps, etc., or may use satellite images that may be purchased or licensed through third party providers.

FIG. **26** is a flowchart illustrating an example process **2600** for identifying building with exterior elevated elements that may require inspection, according to various aspects of the present disclosure. The process **2600**, in some of the present embodiments, may be performed by a processor of a server, such as the server(s) **110** of FIG. **1A**.

With reference to FIG. **26**, satellite generated images of a geographical region may be received (at block **2605**). For example, the server(s) **110** (FIG. **1A**) may receive satellite images that are taken from the geographical region. The satellite images may be publicly available satellite images, or satellite images that may be purchased or licensed through third party providers.

The satellite generated images may then be analyzed (at block **2610**) to identify features corresponding to the exterior elevated elements of buildings in the geographical region. One or more exterior elevated elements may be identified (at block **2615**) in a first plurality of buildings in the geographical location based on the analyses of the satellite generated images.

For examples, the server(s) **110** of FIG. **1A** may search the images for features that corresponds to building structures. Once a building structure is identified, the server(s) **110** may search the exterior boundaries of the building structures for features related to exterior elevated elements, such as, balconies, decks, porches, stairways, landings, walkways, etc. In some embodiments, the server(s) **110** may include image processing software to analyze the images.

In some embodiments, the server(s) **110** may use AI, with an AI model that is trained with satellite generated images that include building structures with exterior elevated elements, satellite generated images that include building structures with no exterior elevated elements, and/or satellite generated images that include no building structures. The AI model may then be used to identify the buildings with exterior elevated elements in satellite images. In some embodiments, the AI may use a deep learning method, for example, to identify the buildings with exterior elevated elements in satellite images.

Images of the first plurality of buildings taken by cameras positioned along streets of geographical may be received (at block **2620**). For example, the server(s) **110** may receive images from a service, such as Google Street View that are taken from street positions. The images may be taken from cameras installed on vehicles, cameras installed on bicycles, cameras carried by persons, etc.

The images taken by the cameras along the streets of the geographical region may be analyzed (at block **2625**) to identify a minimum ground elevation of the exterior elevated elements of the first plurality of buildings. Identify (at block **2630**) the exterior elevated elements of the first plurality of buildings that require inspection based, at least partially, on the minimum ground level elevation of the exterior elevated elements. For example, the server(s) **110** may determine the elevation of the underside of the exterior elevated elements from the grading level (or ground level) of the buildings by analyzing the images taken by the cameras along the streets. Typically, the exterior elevated elements that are close to the grading level (e.g., and without limitations, closer than six feet) may not require inspection by many municipalities.

One or more buildings in the first plurality of buildings may then be identified (at block **2635**) that include the exterior elevated elements requiring inspection based on the determination. The process **2600** may then end. The list of such buildings may be provided to any interested party that may need a list of such buildings for building code enforce-

ment, investment, advertisement (e.g., offering inspection services), etc. The process **26** may then end.

In addition to, or in lieu of using satellite images, some embodiments may provide tabulated data available from government agencies and third parties that list different attributes of buildings in a geographical region. Example of the building attributes that may be provided in this type of tabulated data may include, for example, and without limitations, name of the owner(s), the owner type (e.g., individual, trust, etc.), the owner(s) contact information, owners vesting rights (e.g., joint tenant, revocable trust, trust, survivor, family trust, community property, etc.), the situs direction (e.g., north, south, east, or west), the property's address, the property's legal description (e.g., lot and track number), the property's census track and block number, the property's latitude and longitude address, the land and the building areas, the year built, the data of the issuance of the certificate of opponency, number of bedroom, number of bathrooms, parking area, parking type, patio type, porch type, foundation type, room type, construction type (e.g., wood frame, metal frame, etc.), number of floors, flood zone code, name and address of the homeowner association (if any), etc.

The processor(s) of the server(s) **110**, in some embodiments may analyze (e.g., at block **2610** of process **2600**) the tabulated data to identify buildings that may or may not require inspection. For example, some embodiments may determine that a building is not wood frame or otherwise does not have a wood structure that may need inspection. Some states or municipalities may not require inspection for single story building, or for structures such as a balcony, that may be less than a threshold distance from ground.

In addition to, or in lieu, of the tabulated data, some embodiments may allow user entered data (e.g., entered by an owner, an inspector, a property manager, a buyer, a lender, etc.) to be used to determine whether or not a building may include exterior elevated elements and/or whether or not the exterior elevated elements may require inspection.

FIG. **27** is a flowchart illustrating an example process **2700** for identifying building with exterior elevated elements that may require inspection through a user interface of an electronic device, according to various aspects of the present disclosure. The process **2700**, in some of the present embodiments, may be performed by a processor of a sever, such as the server(s) **110** of FIG. **1A** or by a processor of a client device, such as the client device(s) **120** of FIG. **1A**.

With reference to FIG. **27**, a user interface may be displayed (at block **2705**) at the display of a computing device. FIGS. **28A-28C** illustrate a schematic front view of a client device **120** that may include an application program for determining whether the exterior elevated elements of a building require inspection, according to various aspects of the present disclosure. The figure illustrates, through three stages **2801-2803**, a client device **120** using an application program **2830** to determine whether the exterior elevated elements of a building require inspection.

With reference to FIG. **28A**, stage **2801** shows a user interface (UI) **2800** displayed on a display (e.g., a touchscreen) **2810** of the client device **120**. The client device **120** may be any of the client device **120** of FIG. **1A**.

The UI **2800** may include several selectable UI items (e.g., icons) of several applications **2811-2830**. As shown, the home inspection application program **2830** may be selected in stage **2801**. In response to the selection of the home inspection application program **2830**, the UI **2800**, in stage **2802**, may display several display areas **2841-2843**,

several radio buttons **2851-2852**, and an option **2861** to collect information regarding a building.

Referring back to FIG. **27**, the process may receive (at block **2710**) from the user interface, one or more of the number and the types of the exterior elevated elements of a building, whether the building comprises a wood frame, the minimum ground elevation of the one or more exterior elevated element, the age of the building, whether the one or more exterior elevated elements of the building are used by humans, and the geographical region of the building.

With reference to stage **2802** of FIG. **28B**, the UI may request the address (as shown by **2871**), the year of build (as shown by **2872**), whether the building has a wood frame (as shown by **2873**), and the number of the exterior elevated elements of the building (as shown by **2874**). As shown, the user may have entered the requested information in the display areas **2841-2843** and through the radio buttons **2851-2852**. The option **2861** may be selected in stage **2802** to provide information for each exterior elevated element of the building.

In response, the UI **2800**, in stage **2803**, may request the type of the exterior elevated element (as shown by **2881**), the minimum ground elevation of the exterior elevated element (as shown by **2882**), and whether the exterior elevated element is used by humans (as shown by **2883**). As shown, the user may have entered the response in the display area **2891** and through the radio button **2892-2899**. In stage **2803**, the option **2875** may be selected to provide information for another exterior elevated element. The option **2876** may return the UI to the previous stage.

Referring back to FIG. **27**, the process may determine (at block **2715**) whether the exterior elevated elements of the building require inspection based on one or more of the number of the exterior elevated elements, the type of the exterior elevated elements, whether the building comprises a wood frame, the minimum height of the set of exterior elevated elements of the building from the street level, the age of the building, the certificate of occupancy date of the building, the region of the building, and whether the set of exterior elevated elements of the building is used by humans. The process **2700** may then end.

Some of the above-described features and applications are implemented as software processes that are specified as a set of instructions recorded on a computer readable storage medium (also referred to as computer readable medium). When these instructions are executed by one or more processing unit(s) (e.g., one or more processors, cores of processors, or other processing units), they cause the processing unit(s) to perform the actions indicated in the instructions. Examples of computer readable media include, but are not limited to, CD-ROMs, flash drives, RAM chips, hard drives, EPROMs, etc. The computer readable media does not include carrier waves and electronic signals passing wirelessly or over wired connections.

In this specification, the term "software" is meant to include firmware residing in read-only memory or applications stored in magnetic storage, which may be read into memory for processing by a processor. Also, in some embodiments, multiple software inventions may be implemented as sub-parts of a larger program while remaining distinct software inventions. In some embodiments, multiple software inventions may also be implemented as separate programs. Finally, any combination of separate programs that together implement a software invention described here is within the scope of the invention. In some embodiments, the software programs, when installed to operate on one or more electronic systems, define one or more specific

machine implementations that execute and perform the operations of the software programs.

FIG. 29 conceptually illustrates an electronic system 2900 with which some embodiments of the invention (e.g., the servers 110, the client devices 120 and 155, the snake cameras 150 and the associated controllers 152, the crawler robots 160 and the associated controllers 162, the hubs 170, the controllers 150, etc., described above) are implemented. The electronic system 2900 may be used to execute any of the control, virtualization, or operating system applications described above. The electronic system 2900 may be a computer (e.g., desktop computer, personal computer, tablet computer, server computer, mainframe, blade computer etc.), smartphone, PDA, or any other sort of electronic device. Such an electronic system includes various types of computer readable media and interfaces for various other types of computer readable media. The electronic system 2900 may include a bus 2905, processing unit(s) 2910, a system memory 2920, a read-only memory (ROM) 2930, a permanent storage device 2935, input devices 2940, and output devices 2945.

The bus 2905 collectively represents all system, peripheral, and chipset buses that communicatively connect the numerous internal devices of the electronic system 2900. For instance, the bus 2905 communicatively connects the processing unit(s) 2910 with the read-only memory 2930, the system memory 2920, and the permanent storage device 2935.

From these various memory units, the processing unit(s) 2910 retrieve(s) instructions to execute and data to process in order to execute the processes of the invention. The processing unit(s) may be a single processor or a multi-core processor in different embodiments.

The read-only-memory 2930 stores static data and instructions that are needed by the processing unit(s) 2910 and other modules of the electronic system. The permanent storage device 2935, on the other hand, is a read-and-write memory device. This device is a non-volatile memory unit that stores instructions and data even when the electronic system 2900 is off. Some embodiments of the invention use a mass-storage device (such as a magnetic or optical disk and its corresponding disk drive) as the permanent storage device 2935.

Other embodiments use a removable storage device (such as a flash drive, memory cards, etc.) as the permanent storage device. Like the permanent storage device 2935, the system memory 2920 is a read-and-write memory device. However, unlike storage device 2935, the system memory is a volatile read-and-write memory, such as random access memory. The system memory stores some of the instructions and data that the processor needs at runtime. In some embodiments, the invention's processes are stored in the system memory 2920, the permanent storage device 2935, and/or the read-only memory 2930. From these various memory units, the processing unit(s) 2910 retrieve instructions to execute and data to process in order to execute the processes of some embodiments.

The bus 2905 also connects to the input and output devices 2940 and 2945. The input devices enable the user to communicate information and select commands to the electronic system. The input devices 2940 may include alphanumeric keyboards and pointing devices (also called "cursor control devices"). The input devices 2940, in some embodiments, may include cameras, sensors, microphones, near field communication (NFC) readers, and/or radio-frequency identification (RFID) readers. The input devices 2940, in some embodiments, may include pushbutton, switches, and/

or knobs. The output devices 2945 may include printers, speakers, light sources (e.g., flashlights), and display devices, such as cathode ray tubes (CRT), liquid-crystal displays (LCD), light-emitting diode (LED) displays. Some embodiments may include devices, such as a touchscreen, that function as both input and output devices. The output devices 2945, in some embodiments, may display images generated and/or received by the electronic system.

Finally, as shown in FIG. 29, bus 2905 also couples electronic system 2900 to a network 2925 through a network adapter (not shown). In this manner, the computer may be a part of a network of computers (such as a local area network ("LAN"), a wide area network ("WAN"), an Intranet, or a network of networks, such as the Internet. Any or all components of electronic system 2900 may be used in conjunction with the invention.

Some embodiments include electronic components, such as microprocessors, storage, and memory, that store computer program instructions in a machine-readable or computer-readable medium (alternatively referred to as computer-readable storage media, machine-readable media, or machine-readable storage media). Some examples of such computer-readable media include RAM, ROM, read-only compact discs (CD-ROM), recordable compact discs (CD-R), rewritable compact discs (CD-RW), read-only digital versatile discs (e.g., DVD-ROM, dual-layer DVD-ROM), a variety of recordable/rewritable DVDs (e.g., DVD-RAM, DVD-RW, DVD+RW, etc.), flash memory (e.g., SD cards, mini-SD cards, micro-SD cards, etc.), magnetic and/or solid state hard drives, read-only and recordable Blu-Ray® discs, ultra-density optical discs, any other optical or magnetic media. The computer-readable media may store a computer program that is executable by at least one processing unit and includes sets of instructions for performing various operations. Examples of computer programs or computer code include machine code, such as is produced by a compiler, and files including higher-level code that are executed by a computer, an electronic component, or a microprocessor using an interpreter.

While the above discussion primarily refers to microprocessor or multi-core processors that execute software, some embodiments are performed by one or more integrated circuits, such as application specific integrated circuits (ASICs) or field programmable gate arrays (FPGAs). In some embodiments, such integrated circuits execute instructions that are stored on the circuit itself.

As used in this specification, the terms "computer", "server", "processor", and "memory" all refer to electronic or other technological devices. These terms exclude people or groups of people. For the purposes of the specification, the terms display or displaying means displaying on an electronic device. As used in this specification, the terms "computer readable medium," "computer readable media," and "machine readable medium" are entirely restricted to tangible, non-transitory, physical objects that store information in a form that is readable by a computer. These terms exclude any wireless signals, wired download signals, and any other ephemeral or transitory signals.

While the invention has been described with reference to numerous specific details, one of ordinary skill in the art will recognize that the invention may be embodied in other specific forms without departing from the spirit of the invention. In addition, a number of the figures conceptually illustrate processes. The specific operations of these processes may not be performed in the exact order shown and described. The specific operations may not be performed in one continuous series of operations, and different specific

operations may be performed in different embodiments. Furthermore, the process could be implemented using several sub-processes, or as part of a larger macro process.

In a first aspect, a method of inspecting an exterior elevated element of a building is provided. The method drills a hole into an interior space of the exterior elevated element of the building. The method passes a camera through the hole into the interior space of the exterior elevated element of the building. The interior space of the exterior elevated element encompasses a plurality of wooden surfaces. The method captures a set of one or more images from the wooden surfaces in the interior space of the exterior elevated element by the camera. The method, by the processor of an electronic device, analyzes the set of images to identify one or more of color differences of the wooden surfaces, color intensity differences of the wooden surfaces, and a shape and a size of any cracks on the wooden surfaces. The method determines an existence of wood rot in the interior space of the exterior elevated element based on the analysis.

In a second aspect, a method of identifying buildings with exterior elevated elements that require inspection is provided. The method receives a plurality of satellite generated images of a geographical region. The method, by the processor of a computing device, analyzes the plurality of satellite generated images to identify features corresponding to exterior elevated elements of buildings in the geographical region. The method identifies one or more exterior elevated elements in a first plurality of buildings in the geographical location based on the searching. The method receives images of the first plurality of buildings taken by cameras along streets in the geographical region. The method, by the processor of the computing device, analyzes the images taken by the cameras along the streets to identify a minimum ground elevation of the exterior elevated elements of the first plurality of buildings. The method, by the processor, determines whether the exterior elevated elements of the first plurality of buildings require inspection based, at least partially, on the minimum ground level elevation of the exterior elevated elements. The method identifies one or more buildings in the first plurality of buildings that include exterior elevated elements that require inspection based on the determination.

In an embodiment of the second aspect, the exterior elevated elements of the buildings comprise one or more of decks, porches, balconies, stairways, walkways, and landings.

In another embodiment of the second aspect, determining whether the exterior elevated elements of the first plurality of buildings require inspection further comprises: receiving tabulated data comprising one or more attributes of one or more buildings in the geographical region, comparing the attributes of the first plurality of buildings in the tabulated data with a set of values, and determining whether the exterior elevated elements of the first plurality of buildings require inspection based on the comparison.

In another embodiment of the second aspect, the attributes of a building comprise one or more of whether the building is owner occupied, an address of the building, a year of built of the building, a date of issuance of a certificate of opponency of the building, a number of floors of the building, and a construction type of the building frame.

In another embodiment of the second aspect, comparing the attributes of buildings in the tabulated data with a set of values comprises one or more of determining: whether the property is owner occupied, whether the address of the building indicates that the building is in a particular zone,

whether the year of built of the building is before the threshold date, whether the date of issuance of a certificate of opponency of the building is before the threshold date, whether the number of floors of the building is more than a threshold number, and whether the construction type of the building frame is wood.

An embodiment of the second aspect further comprises: by the processor, using artificial intelligence (AI) or machine learning (ML) to determine a cost and a duration of an inspection of the one or more buildings that require inspection.

In another embodiment of the second aspect, determining whether the exterior elevated elements of the first plurality of buildings require inspection further comprises determining whether the exterior elevated elements are for use by humans.

In a third aspect, a method of determining whether exterior elevated elements of a building require inspection is provided. The method, by a processor of a computing device, displaying a user interface at a display of the computing device. The method receives, from the user interface, one or more of: a number and a type of one or more exterior elevated elements of the building, whether the building comprises a wood frame, a minimum ground elevation of the one or more exterior elevated elements, an age of the building, a certificate of occupancy date of the building, whether the one or more exterior elevated elements of the building are used by humans, and a geographical region of the building. The method by the processor of the computing device, determines whether the exterior elevated elements of the building require inspection based on one or more of the number of the exterior elevated elements, the type of the exterior elevated elements, whether the building comprises a wood frame, the minimum height of the set of exterior elevated elements of the building from the street level, the age of the building, the certificate of occupancy date of the building, the region of the building, and whether the set of exterior elevated elements of the building is used by humans.

An embodiment of the third aspect further comprises receiving a plurality of street level images taken from the building, by the processor of the computing device, searching the plurality of street level images to identify dimensions of one or more of the exterior elevated elements of building, and by the processor of the computing device, using artificial intelligence (AI) or machine learning (ML) to determine a cost and a duration of an inspection of the building.

In a fourth aspect, a method of inspecting a balcony is provided. The method, from the outside of the balcony, detects locations of two wooden joists in an interior of the balcony. There is no access to pass a camera from the outside of the balcony into the interior space of the balcony between the two wooden joists. The interior space of the balcony between the two wooden joists is surrounded by several wooden surfaces including surfaces of the two wooden joists. The method drills a hole into the interior space of the balcony between the two wooden joists. The method passes the camera through the hole into the interior space of the balcony between the two wooden joists. The method captures one or more images by the camera from the wooden surfaces in the interior space of balcony. The method, by the processor of an electronic device, analyzes the one or more images to identify one or more of color differences of the wooden surfaces, color intensity differences of the wooden surfaces, and a shape and a size of any cracks on the wooden surfaces. The method determines the existence of wood rot in the interior space of the balcony based on the analysis.

The method removes the camera from the interior space of the balcony. The method seals the hole.

In an embodiment of the fourth aspect, sealing the hole includes permanently patching the hole.

In another embodiment of the fourth aspect, sealing the hole includes inserting a removable plug into the hole.

In another embodiment of the fourth aspect, detecting two wooden joists in the interior of the balcony includes using an electronic stud finder.

In another embodiment of the fourth aspect, the wooden surfaces further include at least one of a ledger, a blocking, a docking lumber, or plywood.

In another embodiment of the fourth aspect, the camera is installed on a crawler robot, the crawler robot includes several wheels, one or more motors, and a controller connected by a several wires to the crawler robot. The controller includes a processor that is configured to send one or more signals to the one or more motors to move the crawler robot inside the interior space of the balcony and send one or more signals to the camera to turn the camera on or off.

In another embodiment of the fourth aspect, the camera is a snake camera connected by a flexible tube and several wires to a controller comprising a processor. The processor of the controller is configured to send one or more signals to the camera to turn the camera on or off.

An embodiment of the fourth aspect passes a humidity sensor into the hole and receives humidity measurements of the interior space of the balcony between the two wooden joists from the humidity sensor.

An embodiment of the fourth aspect passes a moisture sensor into the hole and receives moisture measurements of the interior space of the balcony between the two wooden joists from the humidity sensor.

Another embodiment of the fourth aspect passes a temperature sensor into the hole and receives temperature measurements of the interior space of the balcony between the two wooden joists from the humidity sensor.

In another embodiment of the fourth aspect, the one or more images comprise one or more still images or one or more video images.

Another embodiment of the fourth aspect transmits the one or more images to one or more remote electronic devices.

Another embodiment of the fourth aspect includes passing an ultrasound probe through the hole into the interior space of the balcony between the two wooden joists; transmitting ultrasound waves by the ultrasound probe; recording, by the ultrasound probe, ultrasound wave echoes reflected from the plurality of wooden surfaces in the interior space of balcony; generating one or more images from the recorded ultrasound wave echoes; by the processor of an electronic device, analyzing the one or more images generated from the recorded ultrasound wave echoes to identify one or more of luminance differences of the wooden surfaces, and a shape and a size of any cracks on the wooden surfaces; and determining an existence of wood rot in the interior space of the balcony based on the analysis.

In a fifth aspect, a method of inspecting a balcony is provided. The method identifies an area of the balcony where there is no access to pass a camera from an outside of the balcony into an interior space of the balcony. The interior space of the balcony encompasses a plurality of wooden surfaces. The method drills a hole into the interior space of the balcony in the identified area. The method passes the camera through the hole into the interior space of the balcony. The method captures one or more images from the wooden surfaces in the interior space of balcony by the

camera. The method, by the processor of an electronic device, analyzes the one or more images to identify one or more of color differences of the wooden surfaces, color intensity differences of the wooden surfaces, and the shape and size of any cracks on the wooden surfaces. The method determines the existence of wood rot in the interior space of the balcony based on the analysis. The method removes the camera from the interior space of the balcony. The method seals the hole.

In an embodiment of the fifth aspect, sealing the hole includes permanently patching the hole.

In another embodiment of the fifth aspect, sealing the hole includes inserting a removable plug into the hole.

In another embodiment of the fifth aspect, the camera is installed on a crawler robot. The crawler robot includes several wheels, one or more motors, and a controller connected by several wires to the crawler robot. The controller includes a processor that is configured to send one or more signals to the one or more motors to move the crawler robot inside the interior space of the balcony and send one or more signals to the camera to turn the camera on or off.

In another embodiment of the fifth aspect, the camera is a snake camera connected by a flexible tube and several wires to a controller that includes a processor. The processor of the controller is configured to send one or more signals to the camera to turn the camera on or off.

In another embodiment of the fifth aspect, the one or more images include one or more still images or one or more video images.

An embodiment of the fifth aspect passes a humidity sensor into the hole and receives humidity measurements of the interior space of the balcony from the humidity sensor.

An embodiment of the fifth aspect passes a moisture sensor into the hole and receives moisture measurements of the interior space of the balcony from the humidity sensor.

Another embodiment of the fifth aspect passes a temperature sensor into the hole and receives temperature measurements of the interior space of the balcony between the two wooden joists from the humidity sensor.

Another embodiment of the fifth aspect transmits the one or more images to one or more external electronic devices.

Another aspect of the fifth embodiment passes an ultrasound probe through the hole into the interior space of the balcony; transmits ultrasound waves by the ultrasound probe; records, by the ultrasound probe, ultrasound wave echoes reflected from the plurality of wooden surfaces in the interior space of balcony; generates one or more images from the recorded ultrasound wave echoes; by the processor of an electronic device, analyzes the one or more images generated from the recorded ultrasound wave echoes to identify one or more of luminance differences of the wooden surfaces, and a shape and a size of any cracks on the wooden surfaces; and determines the existence of wood rot in the interior space of the balcony based on the analysis.

In a sixth aspect, a ventilation window for providing ventilation to an interior space of an exterior elevated element of a building is provide. The exterior elevated element includes one of a deck, a porch, a balcony, a stairway, a walkway, and a landing. The ventilation window includes several railings and several brackets. Each bracket is attached to one or more ball bearings configured to move along a corresponding railing to bring the attached bracket to a vicinity of a joist in the interior space of the exterior elevated element. Each bracket is configured to be connected to a joist to install the ventilation window on an underside of the exterior elevated element. Each ball bearing is configured to be moved to bring the attached bracket to a

vicinity of a joist in the interior space of the exterior elevated element. Each bracket is configured to be connected to a joist to install the ventilation window on the underside of the exterior elevated element.

The above description presents the best mode contemplated for carrying out the present embodiments, and of the manner and process of practicing them, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which they pertain to practice these embodiments. The present embodiments are, however, susceptible to modifications and alternate constructions from those discussed above that are fully equivalent. Consequently, the present invention is not limited to the particular embodiments disclosed. On the contrary, the present invention covers all modifications and alternate constructions coming within the spirit and scope of the present disclosure. For example, the steps in the processes described herein need not be performed in the same order as they have been presented and may be performed in any order(s). Further, steps that have been presented as being performed separately may in alternative embodiments be performed concurrently. Likewise, steps that have been presented as being performed concurrently may in alternative embodiments be performed separately.

What is claimed is:

1. A method of inspecting a balcony, the method comprising:

from an outside of the balcony, detecting locations of two wooden joists in an interior of the balcony, wherein there is no access to pass a camera from the outside of the balcony into an interior space of the balcony between the two wooden joists, wherein the interior space of the balcony between the two wooden joists is surrounded by a plurality of wooden surfaces comprising surfaces of the two wooden joists;

drilling a hole into the interior space of the balcony between the two wooden joists;

passing the camera through the hole into the interior space of the balcony between the two wooden joists;

capturing one or more images by the camera from the plurality of wooden surfaces in the interior space of balcony;

by the processor of an electronic device, analyzing the one or more images to identify one or more of color differences of the wooden surfaces, color intensity differences of the wooden surfaces, and a shape and a size of any cracks on the wooden surfaces;

determining an existence of wood rot in the interior space of the balcony based on the analysis;

removing the camera from the interior space of the balcony; and

sealing the hole.

2. The method of claim 1, wherein sealing the hole comprises permanently patching the hole.

3. The method of claim 1, wherein sealing the hole comprises inserting a removable plug into the hole.

4. The method of claim 1, wherein detecting two wooden joists in the interior of the balcony comprises using an electronic stud finder.

5. The method of claim 1, wherein the plurality of wooden surfaces further comprises at least one of a ledger, a blocking, a docking lumber, or plywood.

6. The method of claim 1, wherein the camera is installed on a crawler robot, the crawler robot comprising:

a plurality of wheels;

one or more motors; and

a controller connected by a plurality of wires to the crawler robot,

wherein the controller comprises a processor configured to:

send one or more signals to the one or more motors to move the crawler robot inside the interior space of the balcony; and

send one or more signals to the camera to turn the camera on or off.

7. The method of claim 1, wherein the camera is a snake camera connected by a flexible tube and a plurality of wires to a controller comprising a processor, wherein the processor of the controller is configured to send one or more signals to the camera to turn the camera on or off.

8. The method of claim 1 further comprising: passing a humidity sensor into the hole; and receiving humidity measurements of the interior space of the balcony between the two wooden joists from the humidity sensor.

9. The method of claim 1 further comprising: passing a moisture sensor into the hole; and receiving moisture measurements of the interior space of the balcony between the two wooden joists from the humidity sensor.

10. The method of claim 1 further comprising: passing a temperature sensor into the hole; and receiving temperature measurements of the interior space of the balcony between the two wooden joists from the humidity sensor.

11. The method of claim 1, wherein the one or more images comprise one or more still images or one or more video images, the method further comprising transmitting the one or more images to one or more remote electronic devices.

12. The method of claim 1 further comprising: passing an ultrasound probe through the hole into the interior space of the balcony between the two wooden joists;

transmitting ultrasound waves by the ultrasound probe; recording, by the ultrasound probe, ultrasound wave echoes reflected from the plurality of wooden surfaces in the interior space of balcony;

generating one or more images from the recorded ultrasound wave echoes;

by the processor of an electronic device, analyzing the one or more images generated from the recorded ultrasound wave echoes to identify one or more of luminance differences of the wooden surfaces, and a shape and a size of any cracks on the wooden surfaces; and

determining an existence of wood rot in the interior space of the balcony based on the analysis.

13. A method of inspecting a balcony, the method comprising:

identifying an area of the balcony where there is no access to pass a camera from an outside of the balcony into an interior space of the balcony, wherein the interior space of the balcony encompasses a plurality of wooden surfaces;

drilling a hole into the interior space of the balcony in the identified area;

passing the camera through the hole into the interior space of the balcony;

capturing one or more images from the wooden surfaces in the interior space of balcony by the camera;

by the processor of an electronic device, analyzing the one or more images to identify one or more of color differences of the wooden surfaces, color intensity

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- differences of the wooden surfaces, and a shape and a size of any cracks on the wooden surfaces;
determining an existence of wood rot in the interior space of the balcony based on the analysis;
removing the camera from the interior space of the balcony; and
sealing the hole.
14. The method of claim 13, wherein sealing the hole comprises permanently patching the hole.
15. The method of claim 13, wherein sealing the hole comprises inserting a removable plug into the hole.
16. The method of claim 13, wherein the camera is installed on a crawler robot, the crawler robot comprising:
a plurality of wheels;
one or more motors; and
a controller connected by a plurality of wires to the crawler robot,
wherein the controller comprises a processor configured to:
send one or more signals to the one or more motors to move the crawler robot inside the interior space of the balcony; and
send one or more signals to the camera to turn the camera on or off.
17. The method of claim 13, wherein the camera is a snake camera connected by a flexible tube and a plurality of wires to a controller comprising a processor, wherein the processor of the controller is configured to send one or more signals to the camera to turn the camera on or off.
18. The method of claim 13, wherein the one or more images comprise one or more still images or one or more

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- video images, the method further comprising transmitting the one or more images to one or more external electronic devices.
19. The method of claim 13 further comprising:
passing a humidity sensor into the hole; and
receiving humidity measurements of the interior space of the balcony from the humidity sensor.
20. The method of claim 13 further comprising:
passing a moisture sensor into the hole; and
receiving moisture measurements of the interior space of the balcony from the humidity sensor.
21. The method of claim 13 further comprising:
passing a temperature sensor into the hole; and
receiving temperature measurements of the interior space of the balcony between the two wooden joists from the humidity sensor.
22. The method of claim 13 further comprising:
passing an ultrasound probe through the hole into the interior space of the balcony;
transmitting ultrasound waves by the ultrasound probe;
recording, by the ultrasound probe, ultrasound wave echoes reflected from the plurality of wooden surfaces in the interior space of balcony;
generating one or more images from the recorded ultrasound wave echoes;
by the processor of an electronic device, analyzing the one or more images generated from the recorded ultrasound wave echoes to identify one or more of luminance differences of the wooden surfaces, and a shape and a size of any cracks on the wooden surfaces; and
determining an existence of wood rot in the interior space of the balcony based on the analysis.

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