US010476501B2

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

(10) **Patent No.: US 10,476,501 B2**
(45) **Date of Patent: Nov. 12, 2019**

(54) **CAPACITIVE SENSOR AND SWITCH ASSEMBLY WITH DECORATIVE CONDUCTIVE COMPONENT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 318 days.

(21) Appl. No.: **15/613,386**

(22) Filed: **Jun. 5, 2017**

(65) **Prior Publication Data**

US 2018/0297513 A1 Oct. 18, 2018

Related U.S. Application Data

(60) Provisional application No. 62/486,483, filed on Apr. 18, 2017.

(51) **Int. Cl.**
B60Q 1/26 (2006.01)
H03K 17/955 (2006.01)

(52) **U.S. Cl.**
CPC ***H03K 17/955*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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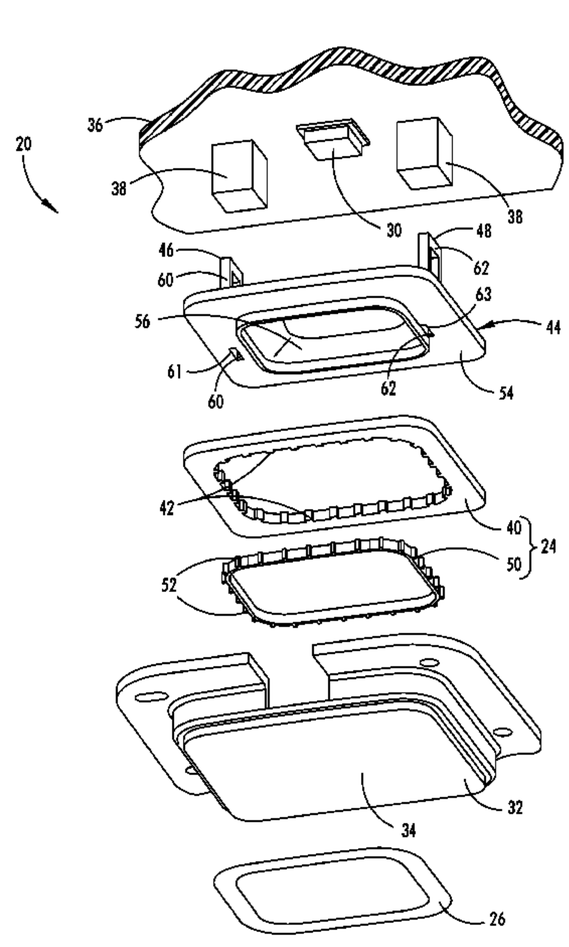
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(57) **ABSTRACT**

A capacitive sensor and switch assembly is provided. The assembly includes a first electrode forming a decorative conductive component on a vehicle, and a second electrode dielectrically isolated from the first electrode and electrically coupled therewith to generate an activation field. The assembly also includes a dielectric layer disposed between the first and second electrodes, and a controller for processing a signal generated from the activation field and sensing an object, wherein the controller determines activation of a switch based on the signal generated from the activation field.

10 Claims, 12 Drawing Sheets



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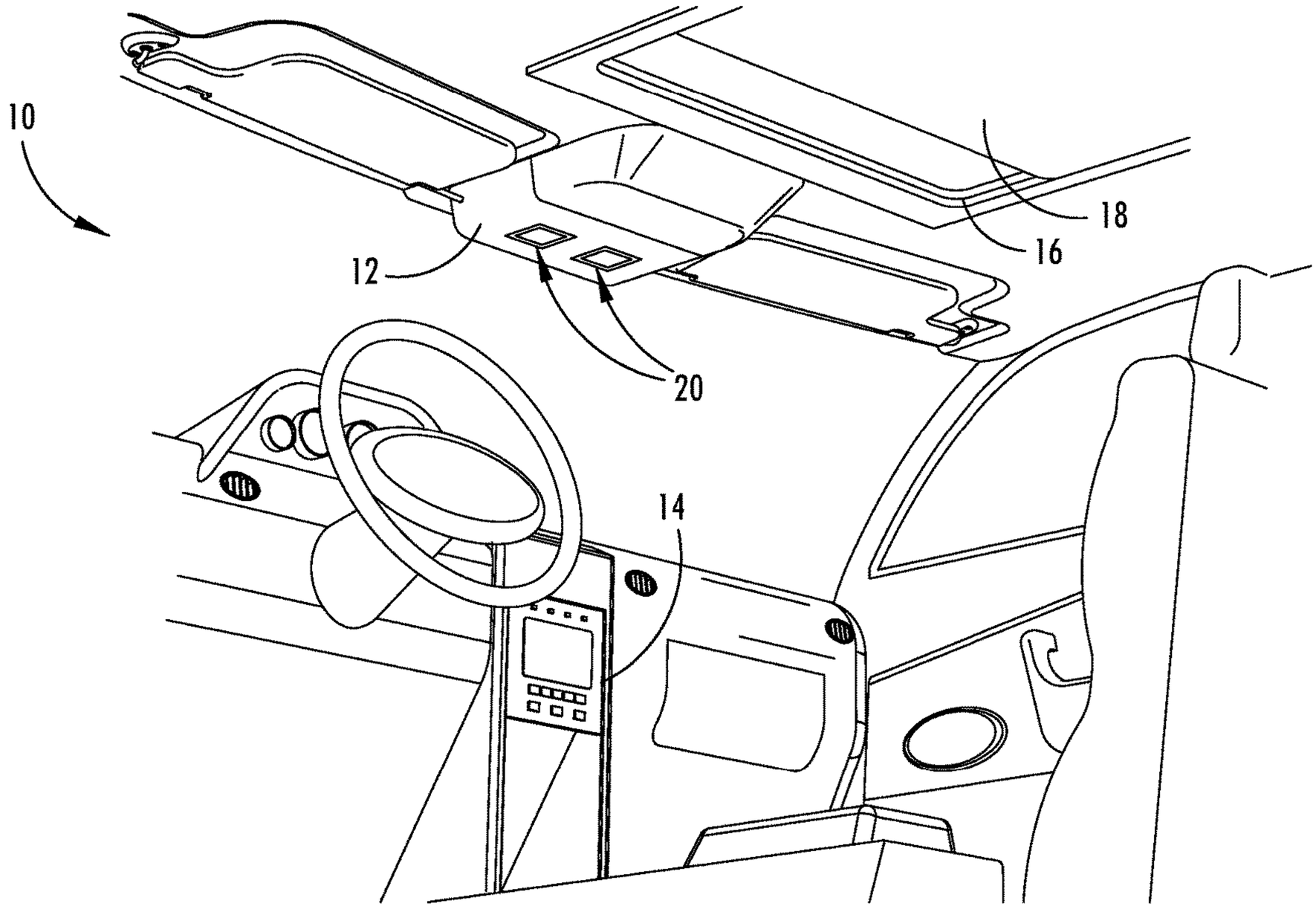


FIG. 1

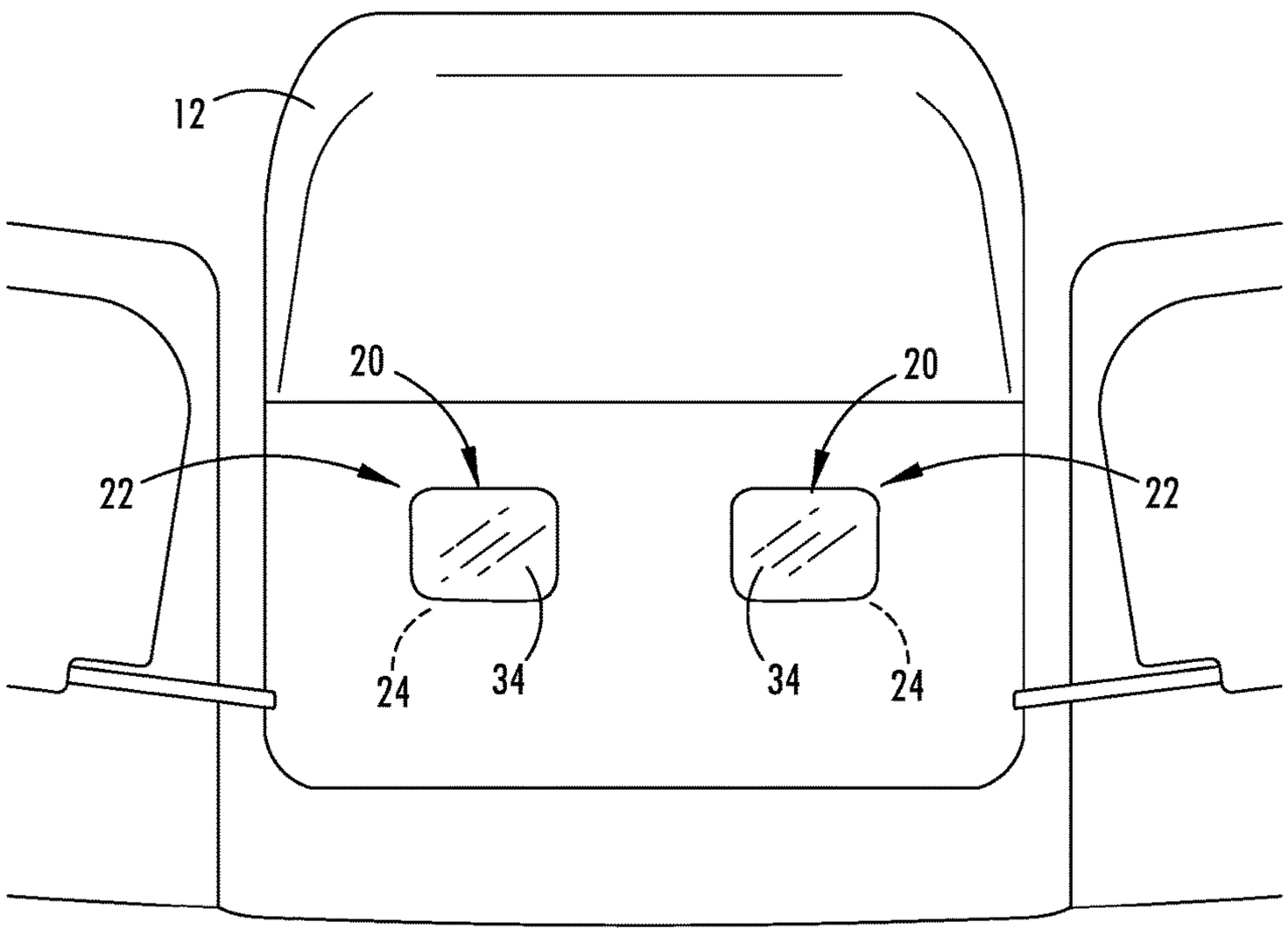


FIG. 2

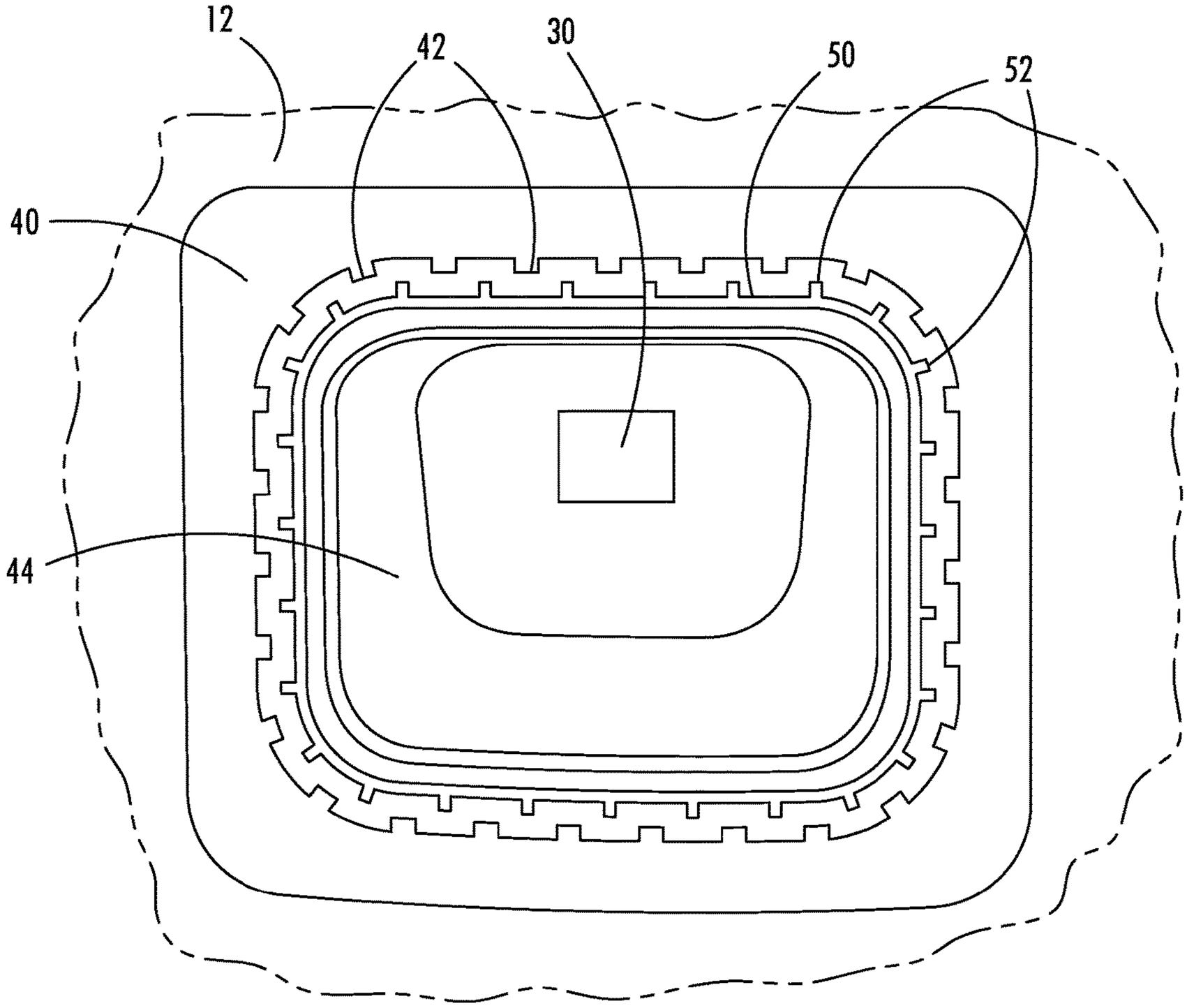


FIG. 3

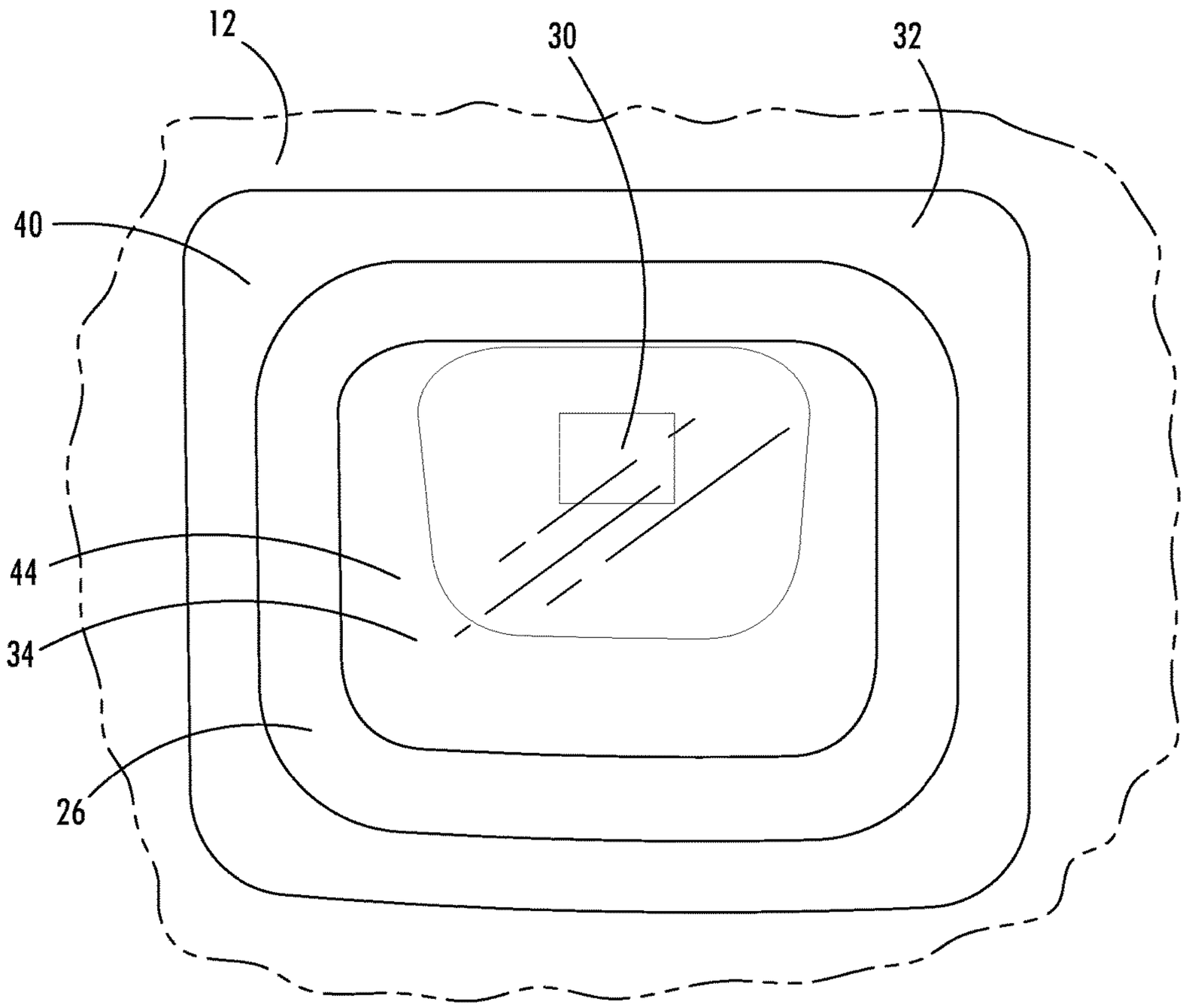


FIG. 3A

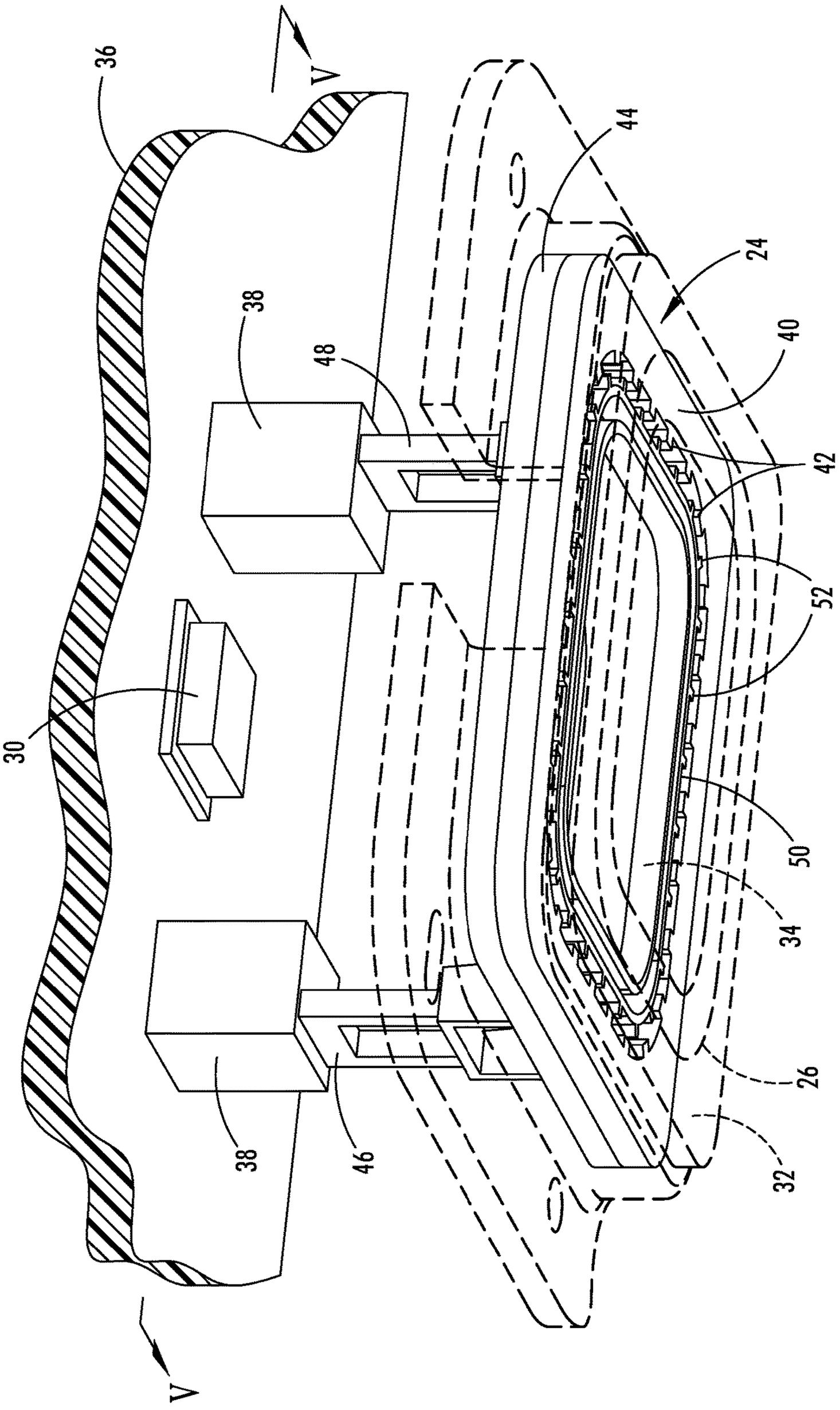


FIG. 4

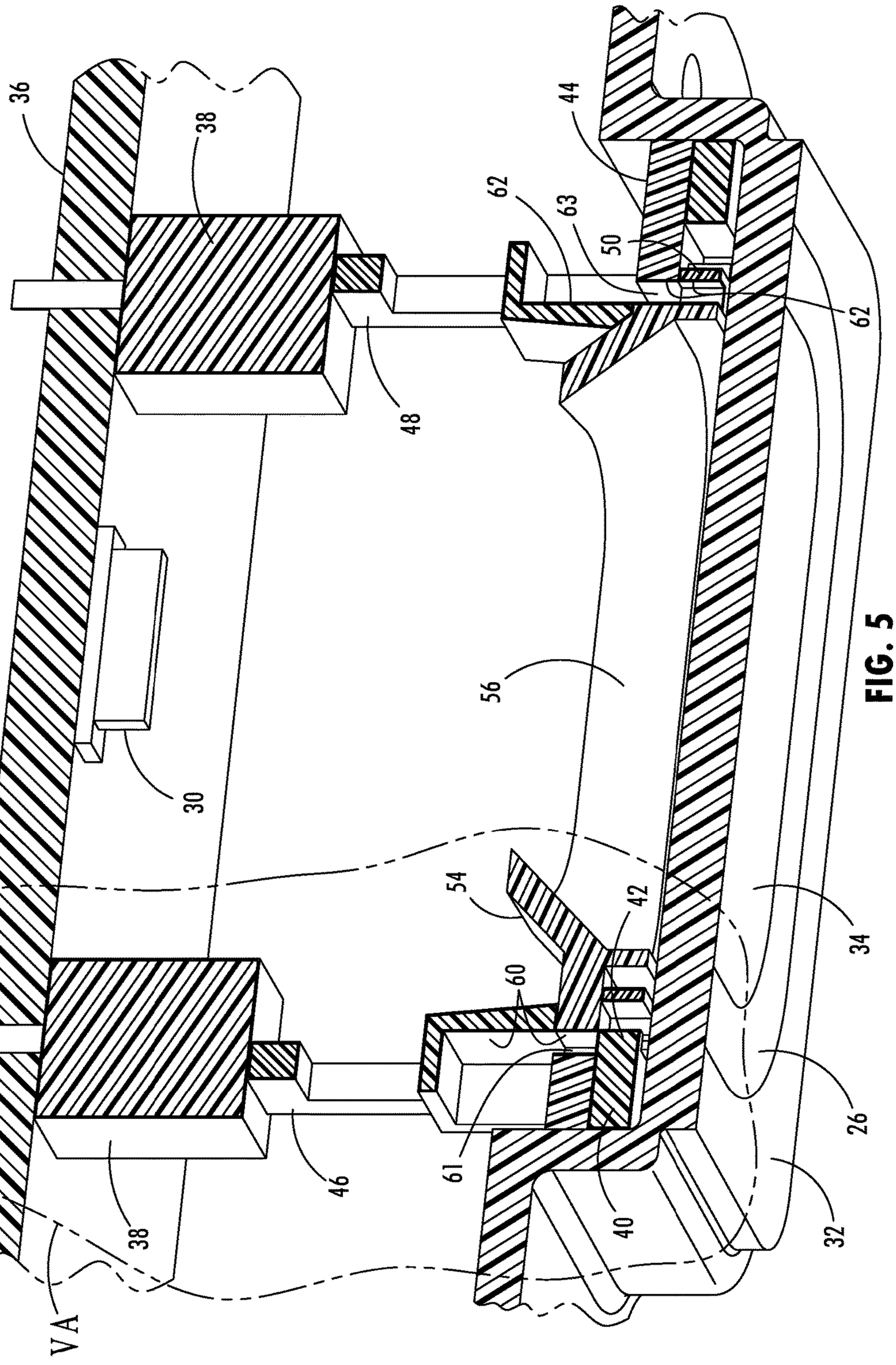


FIG. 5

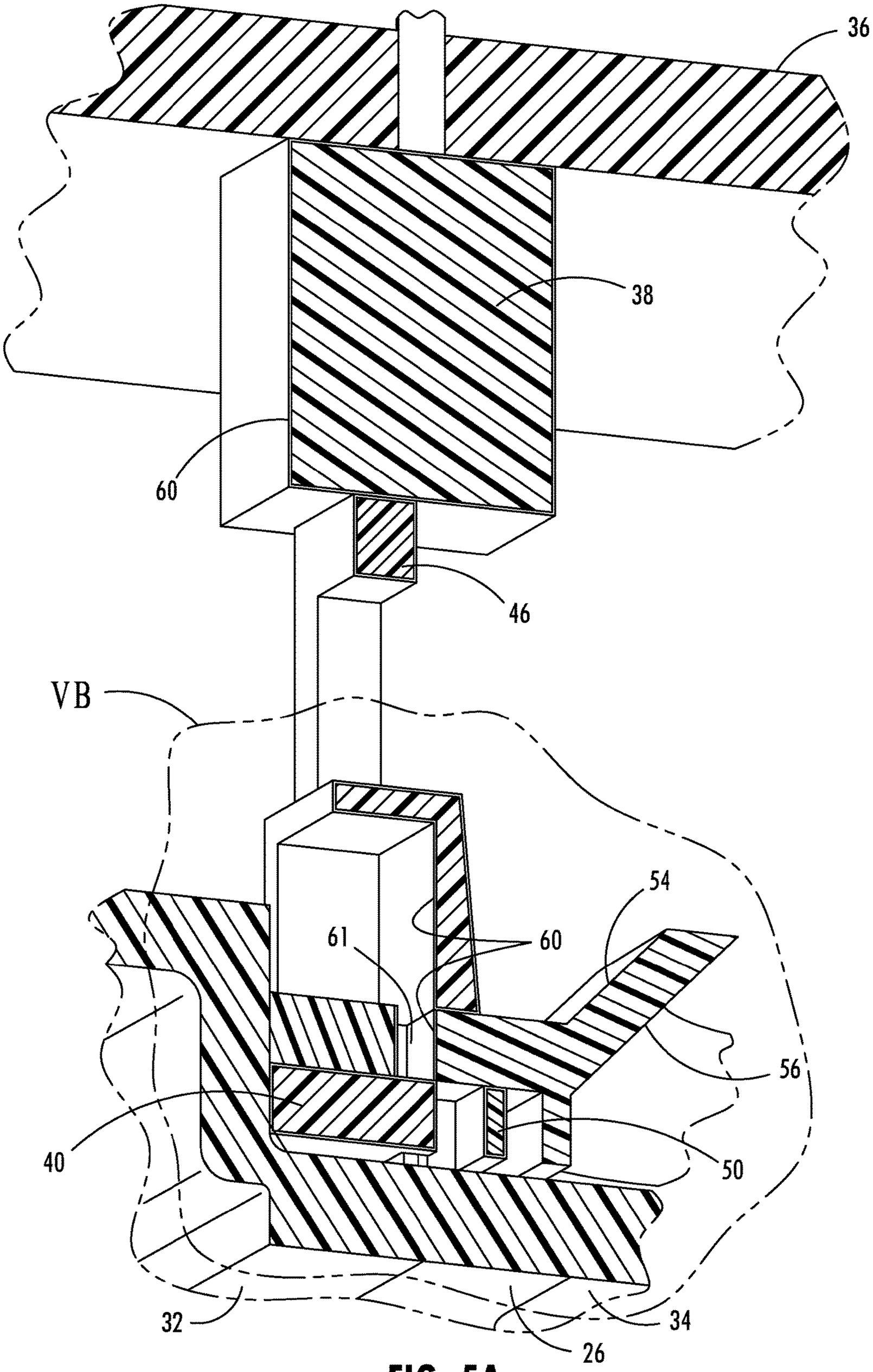


FIG. 5A

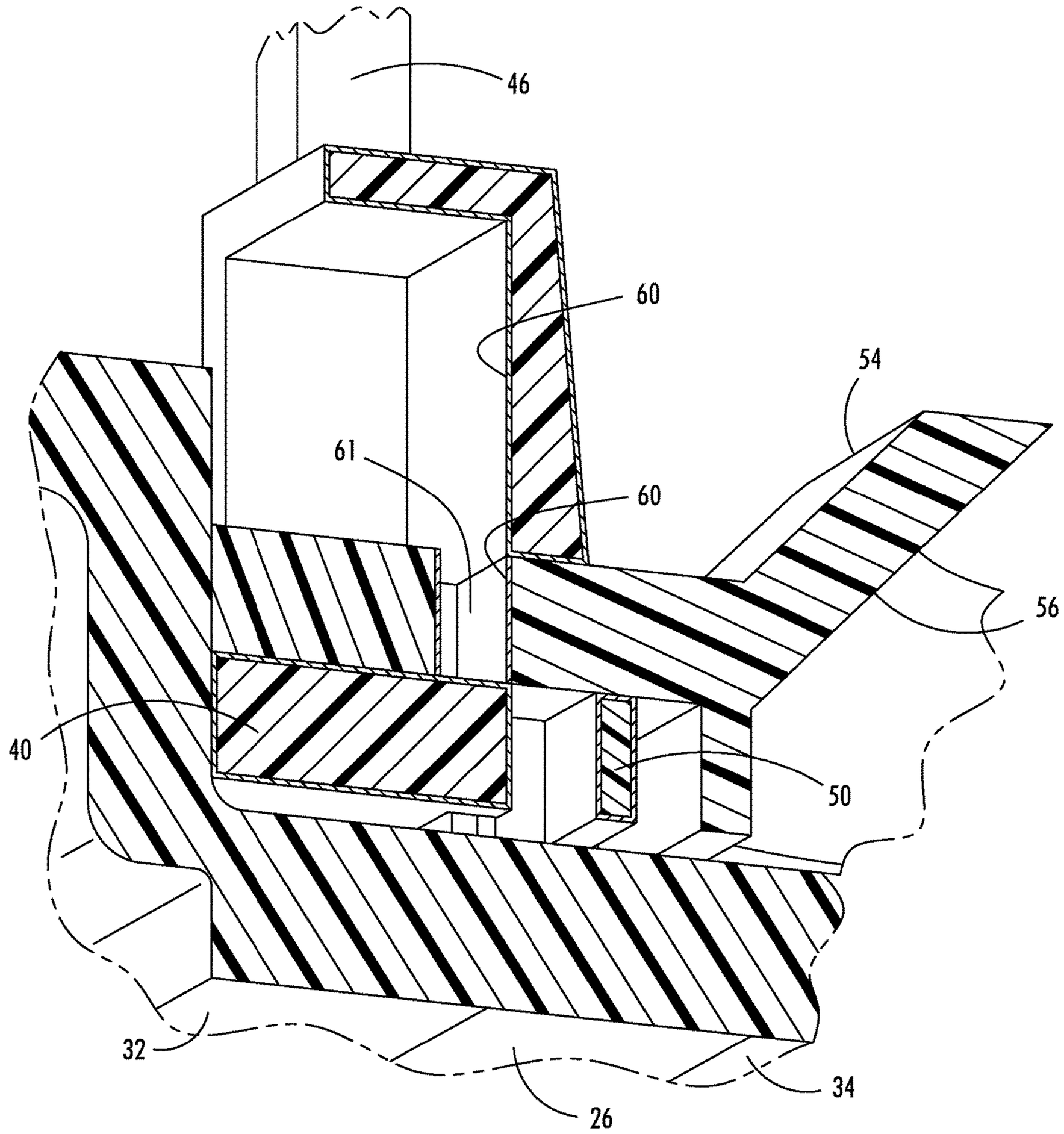


FIG. 5B

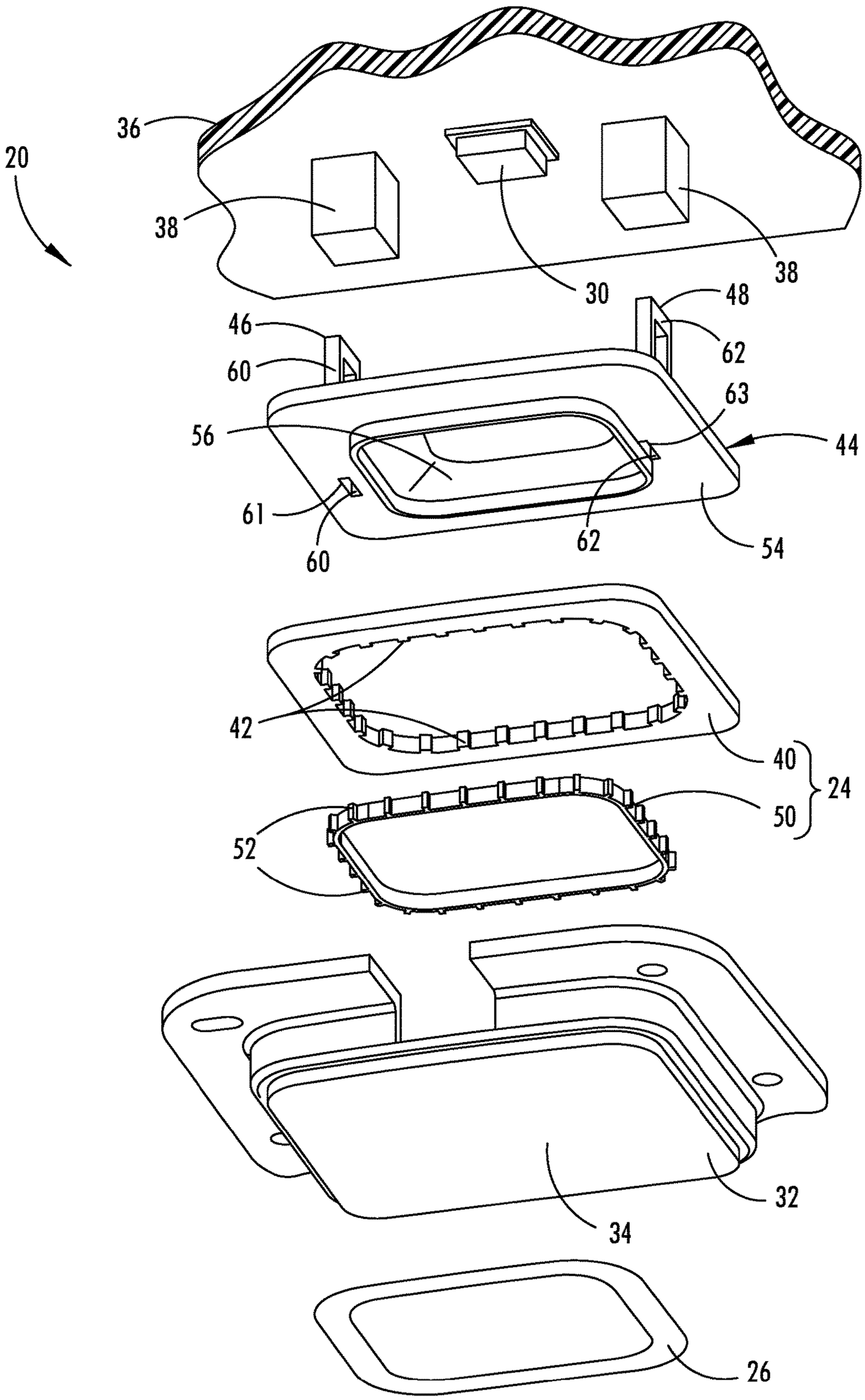


FIG. 6

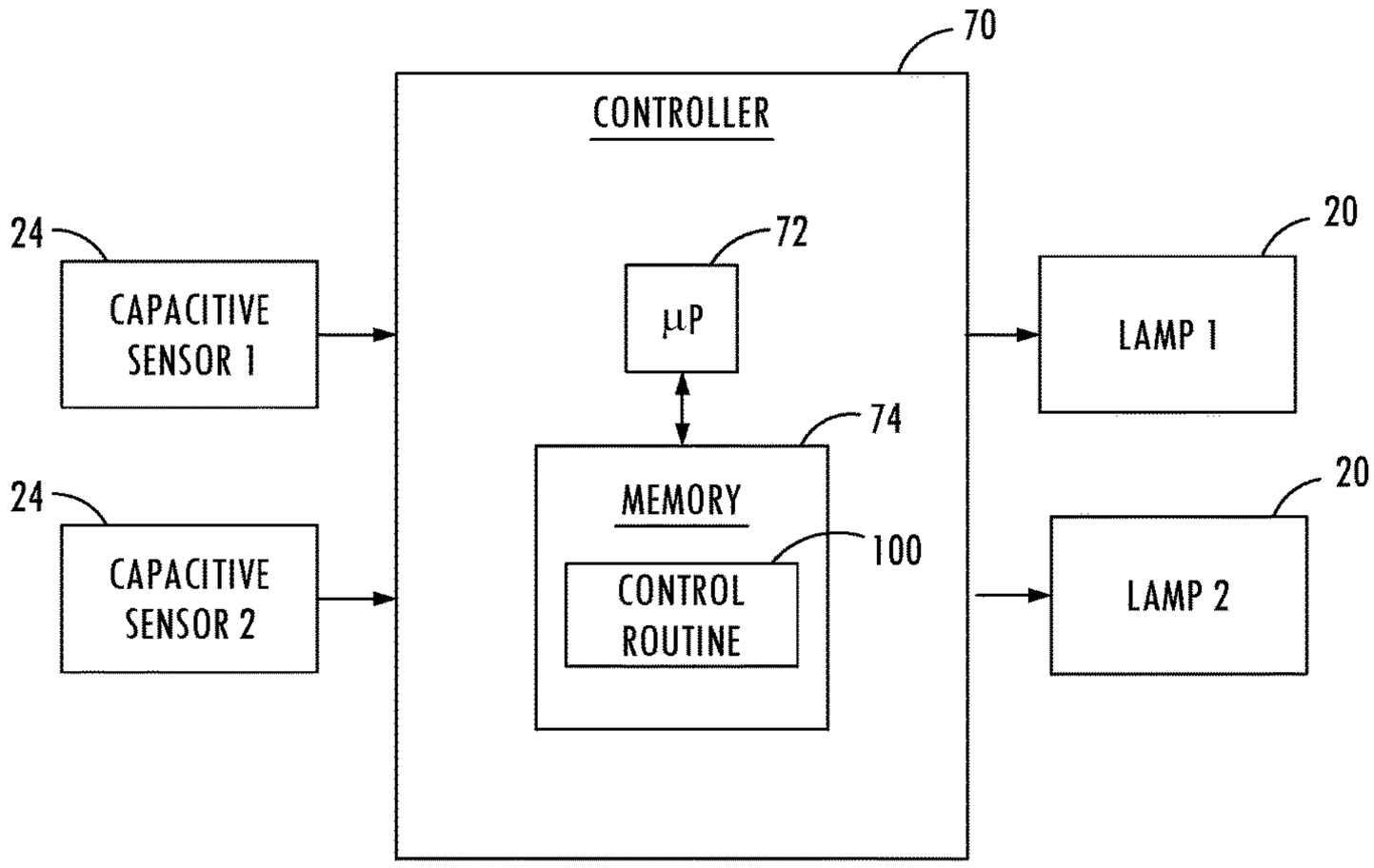

70
CONTROLLER
24
CAPACITIVE SENSOR 1
72
μP
20
LAMP 1
74
MEMORY
100
CONTROL ROUTINE
24
CAPACITIVE SENSOR 2
20
LAMP 2

FIG. 7

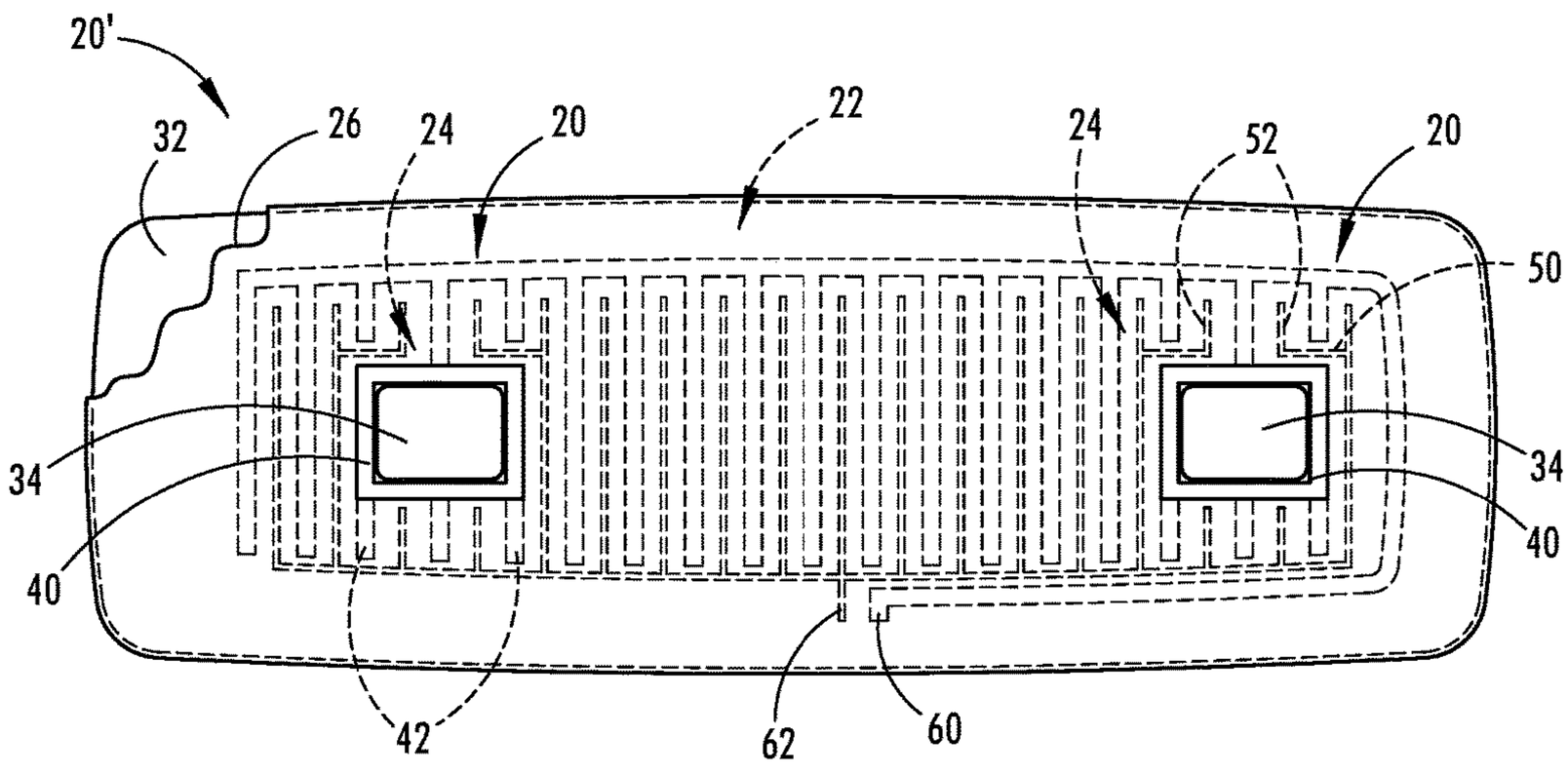

20'
32
26
24
20
22
24
52
20
50
34
40
34
40
42
62
60

FIG. 8

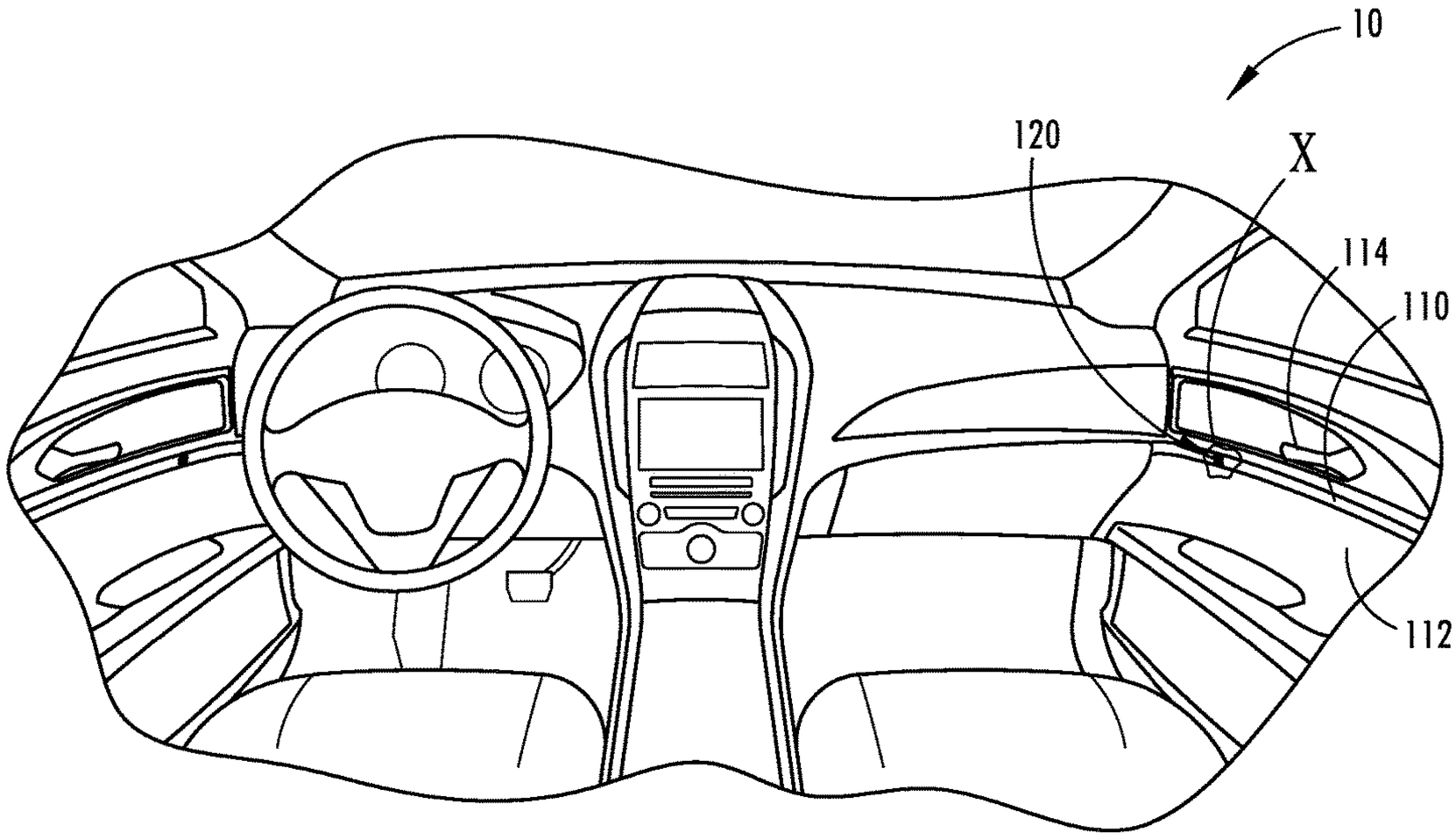


FIG. 9

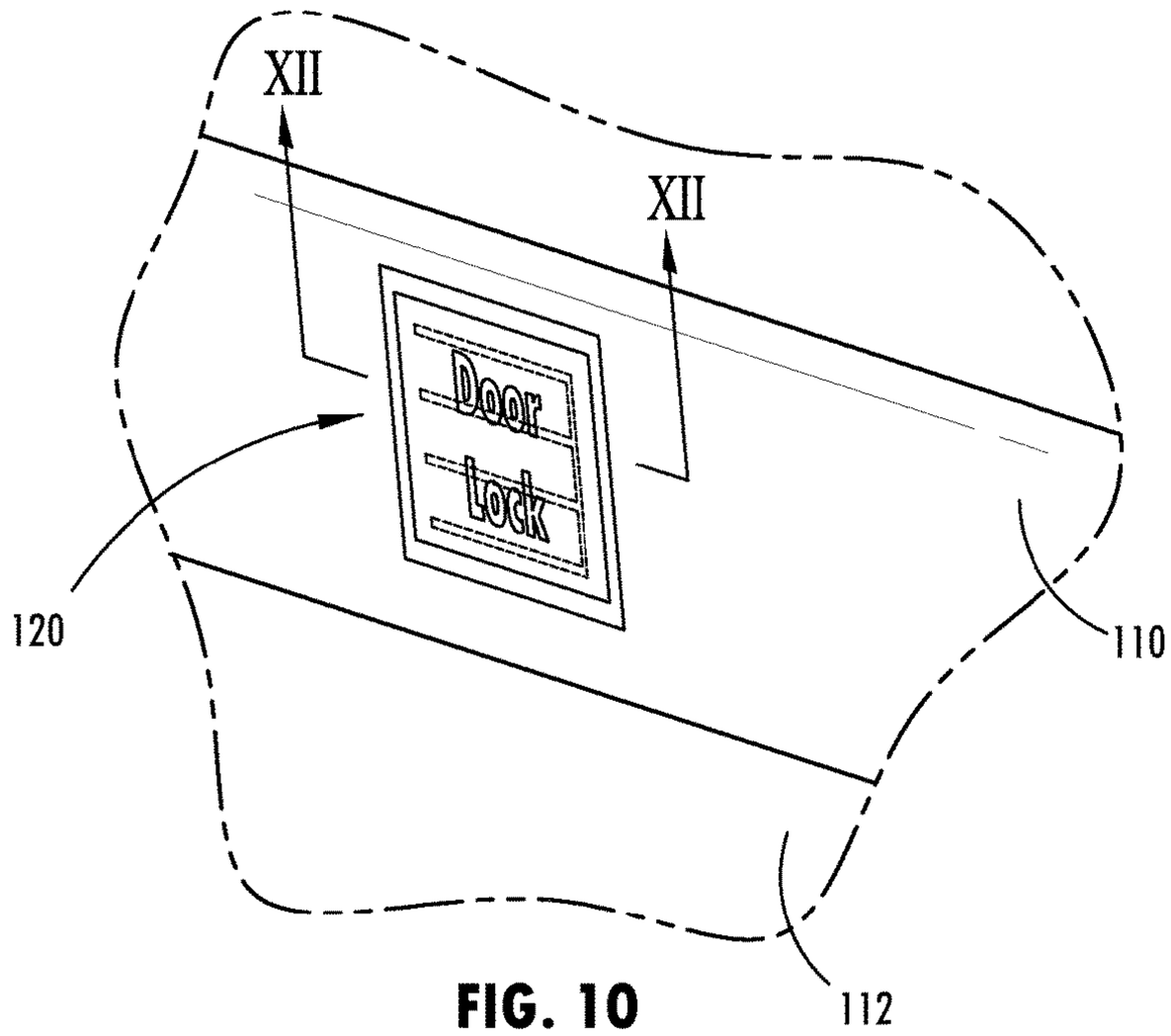


FIG. 10

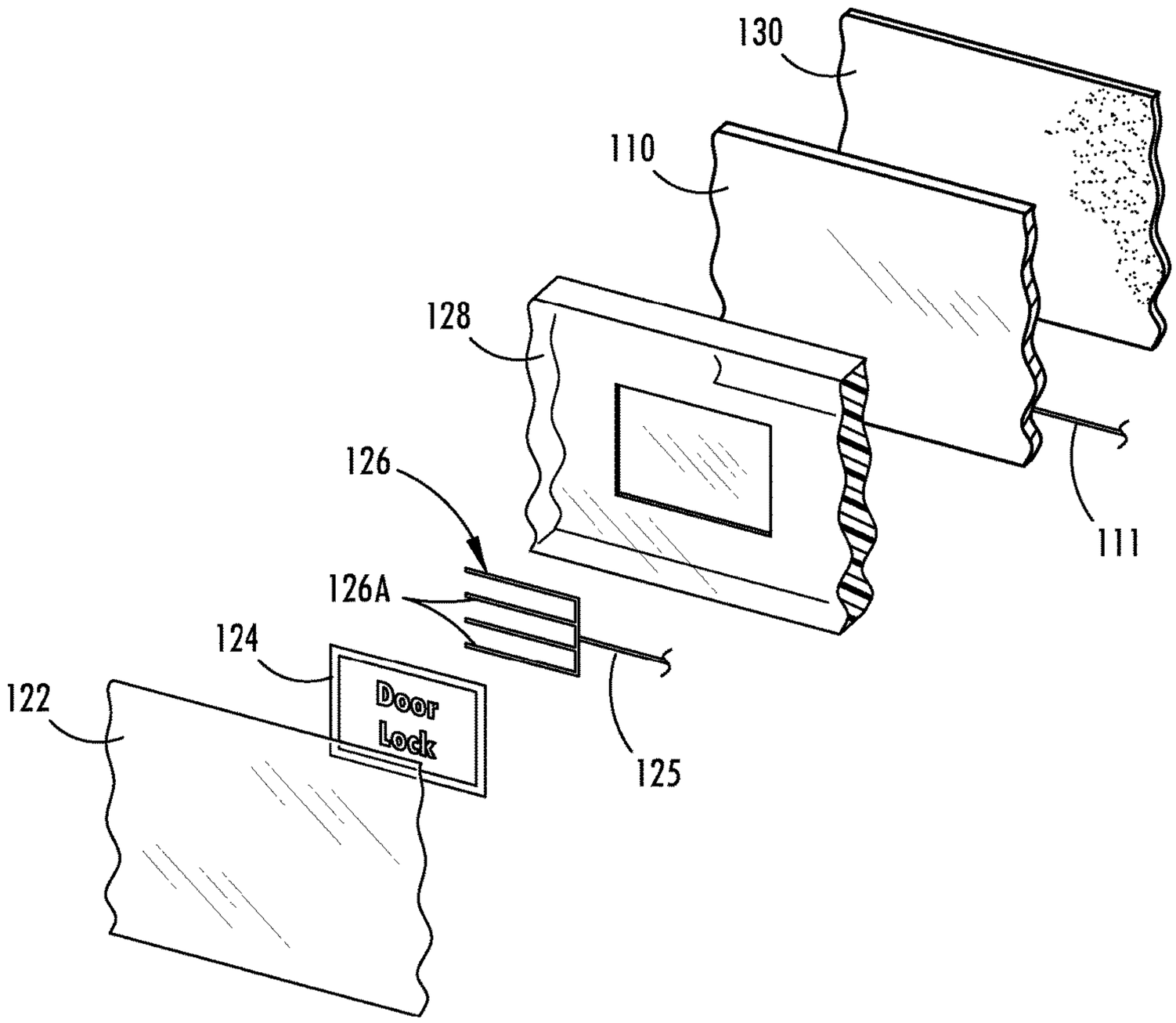


FIG. 11

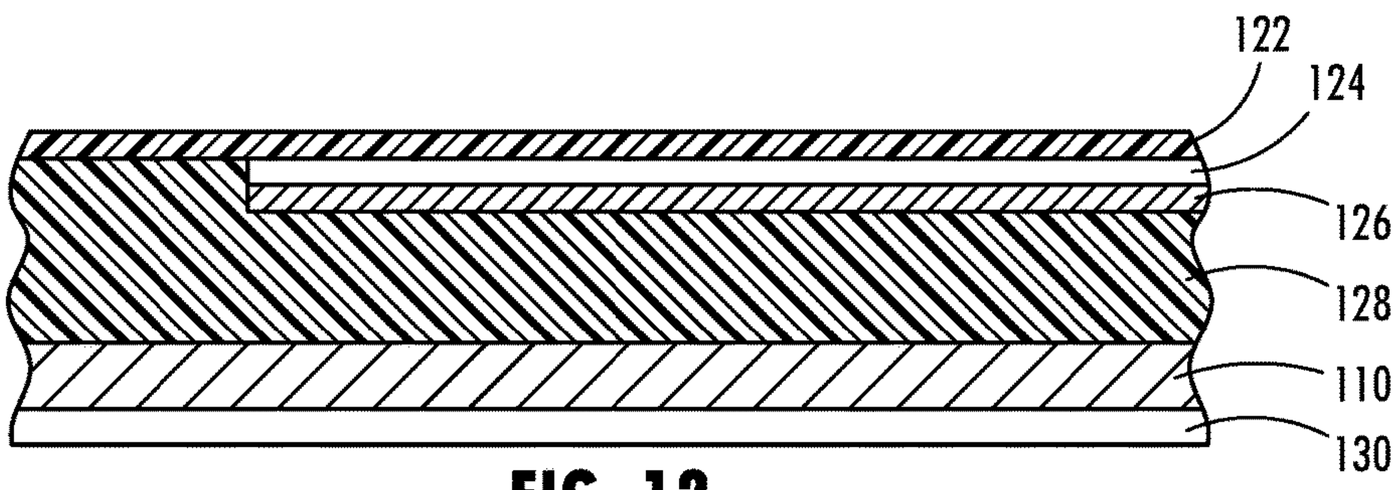


FIG. 12

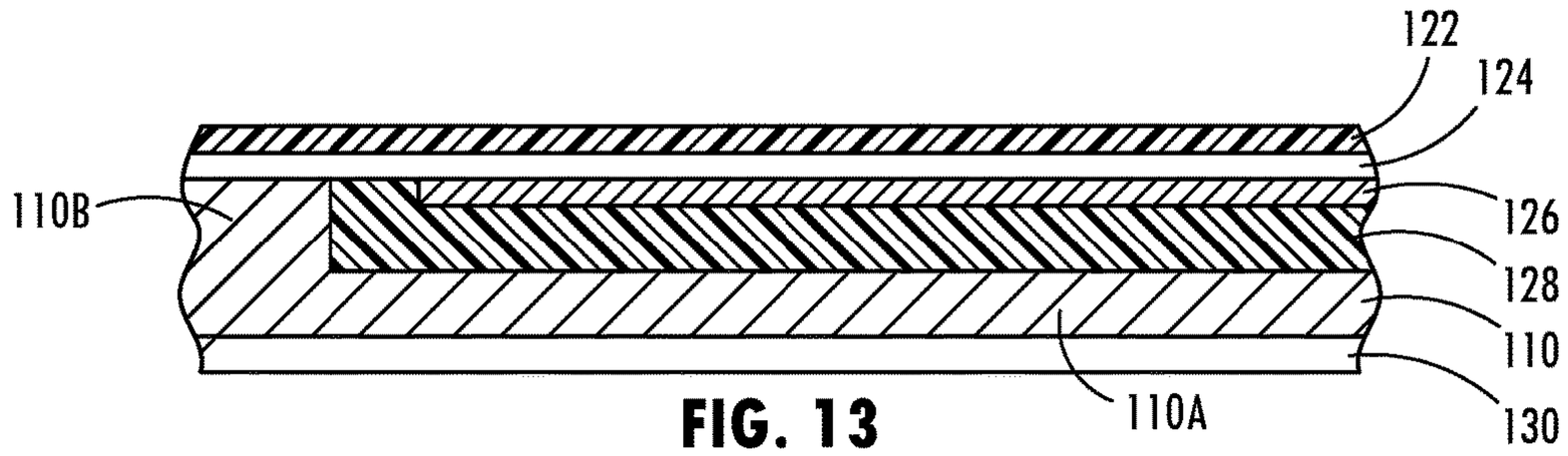


FIG. 13

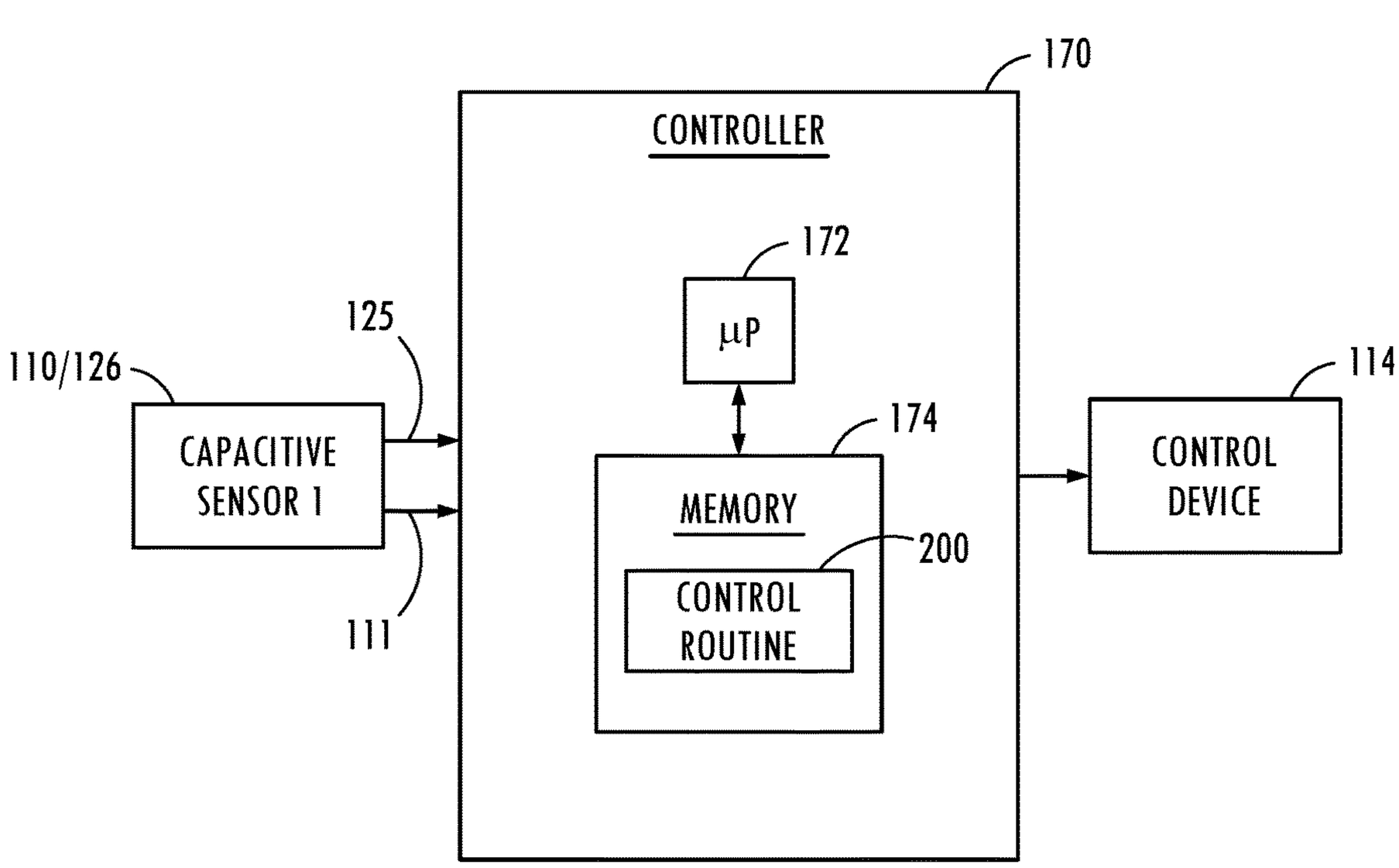

170
CONTROLLER
172
μP
125
110/126
CAPACITIVE SENSOR 1
174
MEMORY
200
CONTROL ROUTINE
111
CONTROL DEVICE
114

FIG. 14

CAPACITIVE SENSOR AND SWITCH ASSEMBLY WITH DECORATIVE CONDUCTIVE COMPONENT

CROSS-REFERENCE TO RELATED APPLICATION

This application claims benefit to U.S. Provisional Patent Application No. 62/486,483, entitled "PROXIMITY SWITCH HAVING SENSOR WITH DECORATIVE METAL," filed on Apr. 18, 2017, the entire disclosure of which is hereby incorporated herein by reference.

FIELD OF THE INVENTION

The present invention generally relates to proximity switches, and more particularly relates to a proximity switch having sensor circuitry that integrates a visible decorative metal.

BACKGROUND OF THE INVENTION

Proximity switches, such as capacitive switches, have been employed for use on vehicles for operating devices such as interior map and dome lighting, moonroofs, and various other devices. Capacitive switches typically employ one or more capacitive sensors to generate a sense activation field and sense changes to the activation field indicative of user actuation of the switch, typically caused by a user's finger in close proximity or contact with the sensor. Capacitive switches are typically configured to detect user actuation of the switch based on comparison of a sensed activation field to a threshold. The capacitive switches are typically configured to include one or more electrodes configured with electrical circuitry formed onto a substrate. It would be desirable to provide for a proximity switch that provides a decorative look and allows reduced components for assembly.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, a capacitive sensor assembly is provided. The capacitive sensor assembly includes a first electrode forming a decorative conductive component, and a second electrode dielectrically isolated from the first electrode and electrically coupled therewith to generate an activation field. The capacitive sensor assembly also includes a dielectric layer disposed between the first and second electrodes, and a controller for processing a signal generated from the activation field and sensing an object based on the signal.

Embodiments of the first aspect of the invention can include any one or a combination of the following features:

- the assembly is located on a vehicle;
- the first electrode comprises a metal trim component on the vehicle;
- the capacitive sensor assembly includes an electric insulation layer disposed between the first electrode and a vehicle mounting assembly;
- the controller determines activation of a switch based on the signal generated from the activation field;
- the second electrode comprises a plurality of electrode fingers that electrically couple with the first electrode to generate the activation field;
- the first electrode is formed on a first layer and the second electrode is formed on a second layer separated by the dielectric layer;

- the decorative conductive component comprises chrome;
- the decorative conductive component comprises aluminum; and
- the controller determines activation of a switch based on the signal generated from the activation field.

According to another aspect of the present invention, a capacitive switch assembly is provided. The capacitive switch assembly includes a first electrode forming a decorative conductive component on a vehicle, and a second electrode dielectrically isolated from the first electrode and electrically coupled therewith to generate an activation field. The capacitive switch assembly also includes a dielectric layer disposed between the first and second electrodes, and a controller for processing a signal generated from the activation field and sensing an object, wherein the controller determines activation of a switch based on the signal generated from the activation field.

Embodiments of the second aspect of the invention can include any one or a combination of the following features:

- the first electrode comprises a metal trim component on the vehicle;
- the metal trim component comprises chrome;
- the metal trim component comprises aluminum;
- the capacitive switch assembly includes an electric insulation layer disposed between the first electrode and a vehicle mounting assembly;
- the second electrode comprises a plurality of electrode fingers that electrically couple with the first electrode to generate the activation field;
- the first electrode is formed on a first layer and the second electrode is formed on a second layer separated by the dielectric layer.

According to a further third aspect of the present invention, a method of forming a capacitive sensor assembly is provided. The method includes the steps of forming a first electrode on a first dielectric layer, forming a second dielectric layer on an opposite side of the first electrode, and forming a second electrode shaped as a decorative conductive component onto an opposite side of the second dielectric layer. The method also includes the steps of generating an activation field with the first and second electrodes, and processing a signal generated by the activation field to sense an object in the activation field.

Embodiments of the third aspect of the invention can include any one or a combination of the following features:

- the controller determines activation of a switch based on the signal generated from the activation field; and
- the assembly is located on a vehicle and the decorative conductive component comprises a metal trim component.

These and other aspects, objects, and features of the present invention will be understood and appreciated by those skilled in the art upon studying the following specification, claims, and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a perspective view of a passenger compartment of an automotive vehicle having an overhead console employing a pair of lamp assemblies having proximity switches, according to one embodiment;

FIG. **2** is an enlarged view of the overhead console further illustrating the lamp assemblies shown in FIG. **1**;

FIG. **3** is an enlarged top view of one lamp assembly and a proximity switch formed thereon with the front lens removed, according to one embodiment;

FIG. **3**A is an enlarged top view of the lamp assembly and proximity switch of FIG. **3** with the opaque layer and lens assembled;

FIG. **4** is a side elevational view of the lamp assembly and the corresponding proximity switch;

FIG. **5** is a cross-sectional view taken through line V-V of FIG. **4** illustrating the lamp and switch assembly;

FIG. **5**A is an enlarged view of section VA of FIG. **5**;

FIG. **5**B is an enlarged view of section VB-VB of FIG. **5**;

FIG. **6** is an exploded view of the lamp assembly and the corresponding proximity switch;

FIG. **7** is a block diagram illustrating a controller for controlling the lamp assembly based on the proximity switch inputs, according to one embodiment;

FIG. **8** is a perspective view of an overhead console with lamp and proximity switch assemblies, according to another embodiment;

FIG. **9** is a perspective view of a passenger compartment of an automotive vehicle having a capacitive sensor and switch assembly formed on a decorative conductive trim component, according to another embodiment;

FIG. **10** is an enlarged view of the capacitive sensor and switch assembly formed on the decorative conductive trim component of FIG. **9**;

FIG. **11** is an exploded view of the capacitive sensor and switch assembly shown in FIG. **10**;

FIG. **12** is a cross-sectional view taken through line XII-XII of FIG. **10** illustrating the capacitive sensor and switch assembly, according to one embodiment;

FIG. **13** is a cross-sectional view taken through line XII-XII of FIG. **9** illustrating the capacitive sensor and switch assembly, according to another embodiment; and

FIG. **14** is a block diagram of the controls for the capacitive sensor and switch assembly of FIG. **10**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. The figures are not necessarily to a detailed design; some schematics may be exaggerated or minimized to show function overview. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention.

Referring to FIGS. **1** and **2**, the interior passenger compartment of an automotive vehicle **10** is generally illustrated having a pair of lamp assemblies **20**, each configured to include a proximity switch **22** and assembled in an overhead console **12**, according to one embodiment. The vehicle **10** shown generally includes the overhead console **12** assembled to the headliner on the underside of the roof or ceiling at the top of the vehicle passenger compartment, generally above the front passenger seating area. Each of the pair of lamp assemblies **20** provides an integral assembly of a lamp and a proximity switch **22** for activating a light source to turn the lamp on and off. Each lamp assembly **20** includes a lens **32** having a light transparent window, a light source disposed behind the lens **32** to illuminate light through the transparent window of the lens **32**, and a proximity switch **22** having one or more proximity sensors **24** disposed proximate or near a perimeter of the transparent window of the lens **32** and generating an activation field proximate to the transparent field of the lens **32** to sense activation of the proximity switch **22** to control activation of the light source. In the embodiment shown, the proximity switch **22** is integrally assembled as part of the lamp assembly **20** in which the central portion, including the transparent window, of the lens **32** serves as a touch or sensing pad. The user may contact the sensing pad or come into close proximity therewith to be detected by the activation field. However, it should be appreciated that the proximity switch **22** may be assembled separate from the lamp assembly **20** and employ its own sensing pad and may control any of a number of devices or functions.

A user may activate the light source by activating the proximity switch **22** integrally provided with the lamp assembly **20**. The lamp may serve as an interior map or reading lamp to provide interior lighting to the vehicle **10**, according to one embodiment. The lamp assembly **20** may also serve as a dome lamp to provide lighting in the interior of the vehicle **10**. It should be appreciated that the lamp may serve to provide lighting to the interior of the vehicle for other uses and the lamp assembly **20** may be located elsewhere on the vehicle **10**. For example, the lamp assembly **20** may be located in the headliner, a visor, a grab handle, a center console, or elsewhere on the vehicle **10**.

Each proximity switch **22** provided in each lamp assembly **20** is shown and described herein as a capacitive switch, according to one embodiment. Each proximity switch **22** includes a proximity sensor **24** that provides a sense activation field to sense contact or close proximity of an object, such as a user's finger, in close relation to the proximity sensor, such as a tap or swiping motion by a user's finger. Thus, the sense activation field generated by the proximity sensor of each proximity switch is a capacitive field in the exemplary embodiment, and the user's finger has electrical conductivity and dielectric properties that cause a change or disturbance in the sense activation field which is detected in a signal generated from the activation field as should be evident to those skilled in the art. However, it should also be appreciated by those skilled in the art that additional or alternative types of proximity sensors can be used, such as, but not limited to, inductive sensors. Exemplary proximity sensors are described in the Apr. 9, 2009, ATMEL® Touch Sensors Design Guide, 10620 D-AT42-04/09, the entire reference hereby being incorporated herein by reference.

The proximity switches may be configured to control other devices. For example, proximity switches **22** may control any of a number of vehicle devices and functions, such as controlling movement of a sunroof or moonroof **16**, controlling movement of a moonroof shade **18**, controlling activation of one or more lighting devices, and controlling various other devices and functions. While the lamp assemblies **20** with proximity switches **22** are shown located in an overhead console **12**, it should be appreciated that the assemblies **20** and proximity switches **22** may be located elsewhere on the vehicle **10**, such as in the dash panel, on other consoles such as a center console, integrated into a touch screen display for a radio or infotainment system such as a navigation and/or audio display, or located elsewhere onboard the vehicle **10** according to various vehicle applications.

The proximity switches **22** are shown and described herein as capacitive switches, according to one embodiment. Each proximity switch **22** includes one or more proximity sensors **24** that provide a sense activation field to sense contact or close proximity of a user in close relation to the one or more proximity sensors **24**, such as a tap or swiping motion by a user's finger. Thus, the sense activation field of

each proximity switch **22** is a capacitive field in the exemplary embodiment and the user's finger has electrical conductivity and dielectric properties that cause a change or disturbance in the sense activation field as should be evident to those skilled in the art. A signal may be generated based on the activation field and processed to detect a user interaction.

Referring to FIGS. **4-6**, the lamp assembly **20** is generally illustrated having a lens **32** made of a transparent material on the front side. The lens **32** may be integrally molded as part of the overhead console **12**. The transparent window **34** of the lens **32** is light transmissive to allow visible light waves to pass through the transparent window **34**. A lamp or light source **30** is disposed rearward of the transparent window **34** of the lens **32** to illuminate light forward through the transparent window **34** of the lens **32**. The light source **30** may include a light emitting diode (LED) mounted to a circuit board **36**, according to one embodiment. Other light sources such as an incandescent bulb or combination of one or more light sources may be employed, according to other embodiments. The lens **32** may be integrally formed as part of the overhead console **12** and having the transparent window **34** formed therein, according to one embodiment. In this embodiment, the transparent window **34** may be molded as part of or into a polymeric material forming the overhead console **12**. According to other embodiments, the lens **32** may be formed as a separate component and assembled to the overhead console **12** as shown. In such embodiments, the lens **32** may be fixedly mounted to the overhead console **12** via fasteners, adhesive or other mounting connection and generally does not move relative to the overhead console **12**.

The lamp assembly **20** includes a proximity switch **22** having a proximity sensor **24** disposed proximate or near a perimeter of and substantially surrounding the central transparent window **34** forming the sensing pad of the lens **32**. The proximity switch **22** has the proximity sensor **24** for generating an activation field proximate to the sensing pad formed by the lens **32** to sense user activation of the proximity switch **22** to control activation of the light source **30**, according to one embodiment. In the embodiment shown, the proximity switch **22** has a single proximity sensor **24** configured to extend substantially on all four sides of the lens **32** to substantially surround the transparent window **34** of the lens **32**. In this embodiment, the proximity switch **22** substantially surrounds the lens **32** to generate an activation field generally across substantially the entire bottom surface of the lens **32** defining the sensing pad and below the lens **32**.

According to one embodiment, the proximity sensor **24** is formed of an electrically conductive metal material that may also serve as a decorative metal trim component. The decorative conductive metal may be plated onto a plastic reflector housing **44** in the upper side of the overhead console **12** about the perimeter of the lens **32**. The conductive metal forms a pair of electrodes **40** and **50** that serve to provide a capacitance which produces the activation field. It should be appreciated that other forms of capacitive sensors may be employed to generate the activation field. It should be appreciated that the activation field generated by the proximity sensor **24** extends below the transparent window of the lens **32** to enable an object, such as a user's finger **28**, hand or other body part to enter the activation-field at the sensing pad to activate the light source **32** on and off. When an object, such as finger sufficiently engages the activation field below the sensing pad, e.g., lens **32**, a disturbance in the activation field is detected such that activation of the proximity switch **22** is initiated so as to either switch the light source **30** on or switch the light source **30** off.

Referring to FIGS. **3-6**, the electrode configuration of the proximity sensor **24** is illustrated, according to one embodiment. Sensor **24** includes an outer electrode **40** having inward extending plates or fingers **42**, and an inner electrode **50** having outward extending plates or fingers **52**. Electrode fingers **42** are interdigitated with electrode fingers **52** to provide a capacitive coupling between the outer electrode **40** and inner electrode **50**. The capacitive coupling produces the activation field.

The outer electrode **40** is coupled to a first plated signal line **60**, while the inner electrode **50** is coupled to a second plated signal line **62**. The first and second plated signal lines **60** and **62** electrically connect to circuitry on the circuit board **36**. A pulsed drive input signal (e.g., voltage) is applied to one of the signal lines **60** and **62**, and an output voltage proportional to the capacitance is received on the other of the signal lines **60** and **62**. The input voltage provides a charge coupling on one of the outer and inner electrodes **40** and **50**, while the other of the outer and inner electrodes **40** and **50** provides a signal indicative of the capacitive coupling between the outer and inner electrodes **40** and **50**. The output signal and the input signal may be processed by control circuitry, such as a controller, to determine whether an object, such as a user's finger, is sufficiently interacting with the activation field to activate the proximity switch **22**.

The electrically conductive material forming the proximity sensor **24**, particularly the electrodes **40** and **50**, is also used to form a decorative metal trim component that is visible on the front side of the proximity switch **22** and lamp assembly **20**. The visible portion of the proximity sensor **24** which is exposed as the decorative metal trim component is shown in FIG. **2** as a ring or bezel generally surrounding the central transparent region **34** of the sensing pad of lens **32**. The portion of the proximity sensor **24** that is visible as a decorative metal trim component from the front side is a portion of the outer electrode **40**. The outer electrode **40** as well as the inner electrode **50** are made of a decorative metal, such as chrome or aluminum that may serve as a shiny decorative trim component. The assembly set forth in the present disclosure advantageously incorporates the decorative conductive material as both a trim component piece and an electrode in an integrated manner.

In the embodiment shown, only a portion of the proximity sensor **24**, particularly only a portion of the outer electrode **40**, is visible from the front side of the lamp assembly **20**. This is because an opaque layer **26** is disposed on the lens **32** to mask or block viewing of other portions or components of the proximity sensor **24**. In the example shown in FIGS. **3**A and **6**, the opaque layer **26** is shown as a ring positioned directly forward or in front of the inner electrode **50** and the fingers **42** of outer electrode **40**. As a result, only the main outer ring of outer electrode **40** is visible as the decorative metal trim component from the front side surrounding the sensing pad of the proximity switch assembly **20**. It should be appreciated that the opaque layer **26** may otherwise be configured to allow for viewing of other portions of the proximity sensor **24**. It should further be appreciated that the opaque layer **26** may not exist such that the entire proximity sensor including the electrodes **40** and **50** that are made of the decorative metal may be viewable from the front side of the assembly, according to other embodiments.

According to one embodiment, the electrically conductive material forming the electrodes **40** and **50** and the first and second plated signal lines **60** and **62** may be formed of a

chrome that is plated onto a thermoplastic or plastic polymer such as a polycarbonate (PC) or acrylonitrile butadiene styrene (ABS) material. The electrodes **40** and **50** and the plated signal lines **60** and **62** may all be formed on the reflector housing **44** in a single electroplating process. The process may include a vacuum metallization process, according to one embodiment. The electrodes **40** and **50** are formed on the front surface **54** of the reflector housing **44**. The reflector housing **44** may have a front reflective surface **56** for reflecting light forward. The plated signal lines **60** and **62** may be formed extending from contact with one of the electrodes **40** and **50**, respectively, via plated holes **61** and **63** and extending through legs or towers **46** or **48** of the reflector housing **44** and into contact with connectors **38** on the circuit board **36**. As such, electrically conductive signal lines are formed connecting one of the electrodes **40** or **42** to one of the towers **46** and **48**. Towers **46** and **48**, in turn, electrically connect to the circuit board **36** through the connectors **38**. As such, control circuitry on the circuit board **36** may provide an electrical signal to one of the electrodes **40** and **42** and may receive a signal from the other of the electrodes **40** and **42** and process the signal to determine activation of the switch. The electrical signal path provided by the plated signal lines **60** and **62** is illustrated in more detail in FIGS. **5-5**B, according to one example. As shown, the chrome plating forms an electrically conductive signal path extending from each of the electrodes **40** and **50** to the circuit board **36**. The underlying polymeric material is a dielectric and is electrically insulated. It should be appreciated that other shapes and sizes and techniques may be employed for providing a signal path extending from the electrodes **40** and **50** to the control circuitry on the circuit board **36**. It should further be appreciated that the plated electrical circuitry may be formed using a coring technique in which an area of polymeric material is cored out and plated to provide an electrical signal path therethrough.

According to one embodiment, the electrically conductive material forming the proximity sensor **24** and decorative metal trim component is chrome, which may be chrome plated onto a polymeric material. However, it should be appreciated that the decorative material may include other materials that have a shiny metal appearance and are electrically conductive including aluminum.

The proximity switch **22** may include control circuitry as shown in FIG. **7**, according to one embodiment. Included is a controller **70** having a microprocessor **72** and memory **74**. The controller **70** may execute one or more control routines **100** as is known in the art via the processor **72** to process capacitor sensor inputs from capacitive sensors **24** and control corresponding devices shown as lamp **1** and lamp **2**, each labeled lamp **20**. The controller **70** may process the capacitive signals sensed by each of the sensors **24** and compare the sensor values to thresholds to determine activation of the corresponding switch **22** indicative of activating one or more control devices, such as one of the lamps **20**.

Referring to FIG. **8**, a lamp and switch assembly **20'** is illustrated having the proximity switch **22** and capacitive sensor **24** configured in an alternative configuration, according to a second embodiment. In this embodiment. In this embodiment, a pair of lamp assemblies **20'** is configured with a proximity switch **22** to turn the lamps on and off. The proximity switch **22** is shown as a capacitive switch having a capacitive sensor **24** with a pair of electrodes **40** and **50** and corresponding interdigitated electrode fingers **42** and **52**. A portion of one electrode is shown surrounding each of the transparent windows **34** of lens **32** so as to form a decorative trim component shown in the shape of a ring surrounding the transparent window **34**. The decorative trim component is a portion of one of the electrodes that is not covered by the opaque layer **26** that covers the remainder of lens **32**. As such, the conductive decorative material e.g., chrome, forming the electrode that is viewable in the unmasked area not covered by opaque layer **26** also serves as the electrode material for forming one of the electrodes of the proximity sensor. It should be appreciated that the opaque layer **26** may cover more or less portions of the proximity sensor **24**, according to other embodiments.

The capacitive sensor and switch assembly **120** is illustrated in FIGS. **9-14**, according to another embodiment. In this embodiment, the assembly **120** includes a first electrode forming a decorative conductive component, such as a metal component and a second electrode dielectrically isolated from the first electrode and electrically coupled therewith to generate an activation field. The assembly **120** has a dielectric layer disposed between the first and second electrodes. The assembly **120** operates the sensor with a controller processing a signal generated from the activation field and sensing an object based on the signal. The assembly **120** may also operate as a switch wherein the controller determines activation of the switch based on the signal generated from the activation field.

Referring to FIGS. **9** and **10**, the interior passenger compartment of an automotive vehicle **10** is illustrated having a capacitive sensor and switch assembly **120** shown formed on a decorative conductive component **110**, which may be a decorative metal trim component, such as chrome, according to one example. The decorative conductive component **110** is shown installed on a door **112** of the vehicle **10** generally proximate to an interior door lock assembly **114**. The capacitive sensor and switch assembly **120** may form a sensor and control switch for activating a control device such as an electronic door lock assembly **114** on door **112** to lock and unlock the electronic door lock assembly. The sensor and switch assembly **120** is assembled onto the decorative conductive component **110** and utilizes the decorative conductive component **110** as one of the capacitive sensor electrodes for forming the capacitive sensor and switch assembly **120**. It should be appreciated that the capacitive sensor and switch assembly **120** can be formed on other decorative conductive components in the interior of the vehicle **10** as well as on the exterior of the vehicle **10**, according to other embodiments.

A user may activate the capacitive sensor and switch assembly **120** by tapping or swiping the user's finger in contact or close proximity to a front sensing surface of the capacitive sensor and switch assembly **120**. By activating the capacitive sensor and switch assembly **120**, the capacitive sensor senses the presence of the user's finger interfacing with the activation field and makes a switch determination to perform a dedicated function which, in this example, is to either lock or unlock the door lock assembly **114**. The sense activation field generated by the sensor is a capacitive field and the user's finger has electrical conductivity and dielectric properties that cause a change or disturbance in the sense activation field which is detected by a signal generated from the activation field as should be evident to those skilled in the art. The switch function performed by the capacitive sensor and switch assembly **120** may control any of a number of vehicle devices and functions, such as those listed above, according to the embodiment of proximity switches **22**.

Referring to FIGS. **10-13**, the capacitive sensor and switch assembly **120** is generally illustrated having various layers formed onto the decorative conductive component

110 which, in turn, is connected or assembled onto the vehicle 10 by way of a vehicle mounting assembly which may include adhesive, fasteners, and other conventional connecting arrangements. The decorative conductive component 110 may include a metal chrome trim component, according to one embodiment. According to another embodiment, the decorative conductive component may include a metal aluminum trim component. The decorative conductive component 110 is a conductive component that has an aesthetically pleasing surface, such as a shiny metal surface, used for forming an A-surface trim component surface, and also serves to form an electrode for the capacitive sensor and switch assembly 120.

The first electrode formed by the decorative conductive component 110 is assembled into the vehicle 10 and electrically isolated from the vehicle 10 by way of an insulation layer 130. The decorative conductive component 110 may be adhered or otherwise assembled onto an interior door panel to form a door trim component in the embodiment shown. The first electrode 110 also has a signal line 111. Insulation layer 130 has dielectric properties to dielectrically isolate the first electrode from vehicle ground and may include an electrically insulated coating or paint, according to one embodiment. One example of the insulation layer 130 is a rubber coating.

Formed onto the front surface of the decorative conductive component 110 is a visibly transparent dielectric layer 128. A second electrode 126 is then formed on the front surface of the dielectric layer 128 such that the second electrode 126 is dielectrically isolated from the decorative conductive component 110 forming the first electrode and electrically coupled therewith to generate an activation field in the form of an electric field. As such, the decorative conductive component 110 forming the first electrode is formed on a first layer and the second electrode 126 is formed on a second layer that is separated from the first layer by way of the dielectric layer 128. Dielectric layer 128 is a visibly transparent material that may include acrylic.

The second electrode 126 has a plurality of electrically conductive plates or fingers 126A and second electrode signal line 125. The first and second electrode signal lines 111 and 125 may electrically connect to circuitry on a circuit board and communicate with a controller. A pulsed drive signal input (e.g., voltage) is applied to one of the first and second signal lines 111 and 125, and an output voltage proportional to the capacitance is received on the other of the first and second signal lines 111 and 125. The input voltage provides a charge coupling on one of the first and second electrodes 110 and 126, while the other of the first and second electrodes 110 and 126 provides a signal indicative of the capacitive coupling between the first and second electrodes 110 and 126. The output signal and input signal may be processed by control circuitry, such as a controller, to determine whether an object, such as a user's finger, is sensed sufficiently interacting with the activation field to activate the capacitive sensor and switch assembly 120. The second electrode 126 is preferably formed of a substantially visually transparent conductive material such as indium tin oxide (ITO), according to one embodiment. As such, the second electrode 126 is visually transparent when viewed from the front side.

Shown formed in front of the first electrode 126 is a printed ink layer 124 which may include printed indicia for defining the sensing area of the switch assembly and an icon or description of the function of the switch, such as "door lock," according to one example. The printed ink layer 124 is a dielectric such that it is electrically nonconductive. The printed ink layer 124 may be located on either the front or rear side of the second electrode 126. Disposed on the front surface of the capacitive sensor and switch assembly 120 is a visually transparent dielectric layer 122 such as a film which provides a protective layer over the front surface of the switch assembly 120. As such, the dielectric layer 122, second electrode 126 and dielectric layer 128 are visually transparent materials that allow a viewer to look from the front side forward and view the decorative conductive component 110 which forms the first electrode, and also to view the indicia on the printed ink layer 124.

In the embodiment shown in FIG. 12, the decorative conductive component 110 forming the first electrode is formed in a substantially planar arrangement on a first layer that is dielectrically isolated from the second electrode 126 formed on a second layer and separated therefrom via the dielectric layer 128. As such, the dielectric layer 128 is sandwiched between the first and second electrode to form the capacitive sensor. The decorative conductive component 110 may include a decorative metal, such as metal chrome or aluminum that may be formed with vacuum metallization, according to one embodiment. The decorative conductive component may be plated or solid.

In the embodiment shown in FIG. 13, the decorative conductive component 110 is shown forming a first horizontal layer 110A below the second electrode 128 and has a vertical upstanding second portion 110B that somewhat surrounds the second electrode 126. The second portion 120B may provide for enhanced electrical coupling between the first electrode 110 and the second electrode 126, particularly near the perimeter of the interface of the first and second electrodes. In this embodiment, the decorative conductive component 110 may be made of a conductive polymeric material, according to one embodiment. The conductive polymeric material may be a conductive plastic that has carbon or steel fibers to provide electronic conduction and may give a shiny metallic appearance on the front surface. Accordingly to another embodiment, the decorative conductive component 110 may be made of chrome or aluminum which may be formed with vacuum metallization.

The capacitive sensor and switch assembly 120 may include control circuitry as shown in FIG. 14, according to one embodiment. Included is a controller 170 having a microprocessor 172 and memory 174. The controller 170 may execute one or more control routines 200 as is known in the art via the processor 172 to process capacitive sensor signals on signal lines 111 and 125 from the respective capacitive sensor electrodes 110 and 126 and control one or more control devices 114 based on the sensed capacitance. The controller 170 may process capacitive signals sensed by the sensor electrodes and compare the sensor values to one or more thresholds to determine activation of the switch indicative of a control input for activating one or more control devices 114, such as a door lock assembly.

Accordingly, the present capacitive sensor and switch assembly 120 advantageously integrates a decorative feature of a conductive material with a proximity sensor, specifically a capacitive sensor, to form a capacitive proximity switch. The capacitive proximity switch advantageously employs a single conductive material to both form an electrically conductive sensing component and decorative trim component and thereby eliminates the need for a separate metal trim part which may otherwise interfere with the sensing ability of the proximity sensor and switch. In addition, the capacitive sensor may have fewer components for assembly.

It is to be understood that variations and modifications can be made on the aforementioned structure without departing from the concepts of the present invention, and further it is to be understood that such concepts are intended to be covered by the following claims unless these claims by their language expressly state otherwise.

What is claimed is:

1. A capacitive sensor assembly comprising:

a first electrode forming a decorative conductive component comprising a metal trim component made of chrome or aluminum, wherein the first electrode is viewable by a user;

a second electrode dielectrically isolated from the first electrode and electrically coupled therewith to generate an activation field;

a dielectric layer disposed between the first and second electrodes;

a controller for processing a signal generated from the activation field and sensing an object based on the signal; and

an electric insulation layer disposed between the first electrode and a vehicle mounting assembly, wherein the assembly is located on a vehicle.

2. The capacitive sensor assembly of claim **1**, wherein the controller determines activation of a switch based on the signal generated from the activation field.

3. The capacitive sensor assembly of claim **1**, wherein the second electrode comprises a plurality of electrode fingers that electrically couple with the first electrode to generate the activation field.

4. The capacitive sensor assembly of claim **1**, wherein the first electrode is formed on a first layer and the second electrode is formed on a second layer separated by the dielectric layer.

5. The capacitive sensor assembly of claim **1**, wherein the controller determines activation of a switch based on the signal generated from the activation field.

6. A capacitive switch assembly comprising:

a first electrode forming a decorative conductive component on a vehicle comprising a metal trim component made of chrome or aluminum, wherein the first electrode is viewable by a user;

a second electrode dielectrically isolated from the first electrode and electrically coupled therewith to generate an activation field;

a dielectric layer disposed between the first and second electrodes;

a controller for processing a signal generated from the activation field and sensing an object, wherein the controller determines activation of a switch based on the signal generated from the activation field; and

an electric insulation layer disposed between the first electrode and a vehicle mounting assembly.

7. The capacitive sensor assembly of claim **6**, wherein the second electrode comprises a plurality of electrode fingers that electrically couple with the first electrode to generate the activation field.

8. The capacitive sensor assembly of claim **6**, wherein the first electrode is formed on a first layer and the second electrode is formed on a second layer separated by the dielectric layer.

9. A method of forming a capacitive sensor assembly, comprising:

forming a first electrode on a first dielectric layer;

forming a second dielectric layer on an opposite side of the first electrode;

forming a second electrode shaped as a decorative conductive component comprising a metal trim component made of chrome or aluminum onto an opposite side of the second dielectric layer, wherein the second electrode is viewable by a user;

disposing an electric insulation layer between the second electrode and a vehicle mounting assembly, wherein the assembly is located on a vehicle;

generating an activation field with the first and second electrodes; and

processing a signal generated by the activation field to sense an object in the activation field.

10. The capacitive sensor assembly of claim **9**, wherein the controller determines activation of a switch based on the signal generated from the activation field.

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