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

(10) **Patent No.: US 12,388,168 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **PORTABLE ELECTRONIC DEVICE HAVING INTEGRATED ANTENNA ELEMENTS**

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(72) Inventors: **Michael R. Parker**, Cupertino, CA (US); **Devon K. Copeland**, Cupertino, CA (US); **Jody C. Fu**, Cupertino, CA (US); **Tyler S. Atura Bushnell**, Mountain View, CA (US); **Trent Canales**, Roseville, CA (US)

(73) Assignee: **APPLE INC.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 62 days.

(21) Appl. No.: **17/903,994**

(22) Filed: **Sep. 6, 2022**

(65) **Prior Publication Data**

US 2023/0091853 A1 Mar. 23, 2023

Related U.S. Application Data

(60) Provisional application No. 63/247,674, filed on Sep. 23, 2021, provisional application No. 63/344,473, filed on May 20, 2022.

(51) **Int. Cl.**

H01Q 1/27 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H01Q 1/273*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/44*** (2013.01); ***H01Q 13/10*** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/273; H01Q 1/44; H01Q 13/10; H01Q 13/106; H01Q 21/064

See application file for complete search history.

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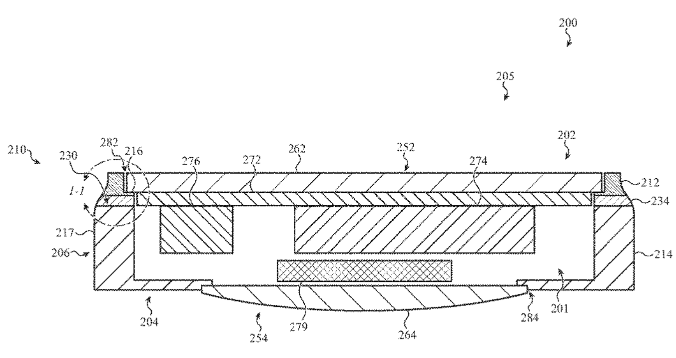
Primary Examiner — Ab Salam Alkassim, Jr.

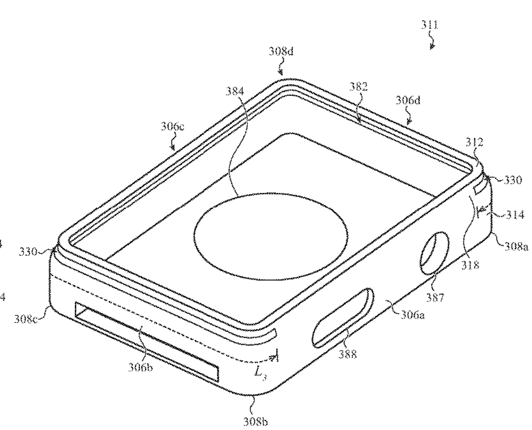
(74) *Attorney, Agent, or Firm* — Brownstein Hyatt Farber Schreck, LLP

(57) **ABSTRACT**

Housings for electronic devices are disclosed, as well as electronic devices including the housings. A wireless communication system of the electronic device may include an antenna element within a display assembly. The antenna element within the display assembly may be operatively coupled to a conductive upper portion of the housing. The housing may define a slot between the conductive upper portion and a conductive lower portion of the housing, and a dielectric material may be positioned within the slot.

20 Claims, 23 Drawing Sheets





(51) **Int. Cl.**
H01Q 1/44 (2006.01)
H01Q 13/10 (2006.01)
H01Q 21/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/106*** (2013.01); ***H01Q 21/064*** (2013.01)

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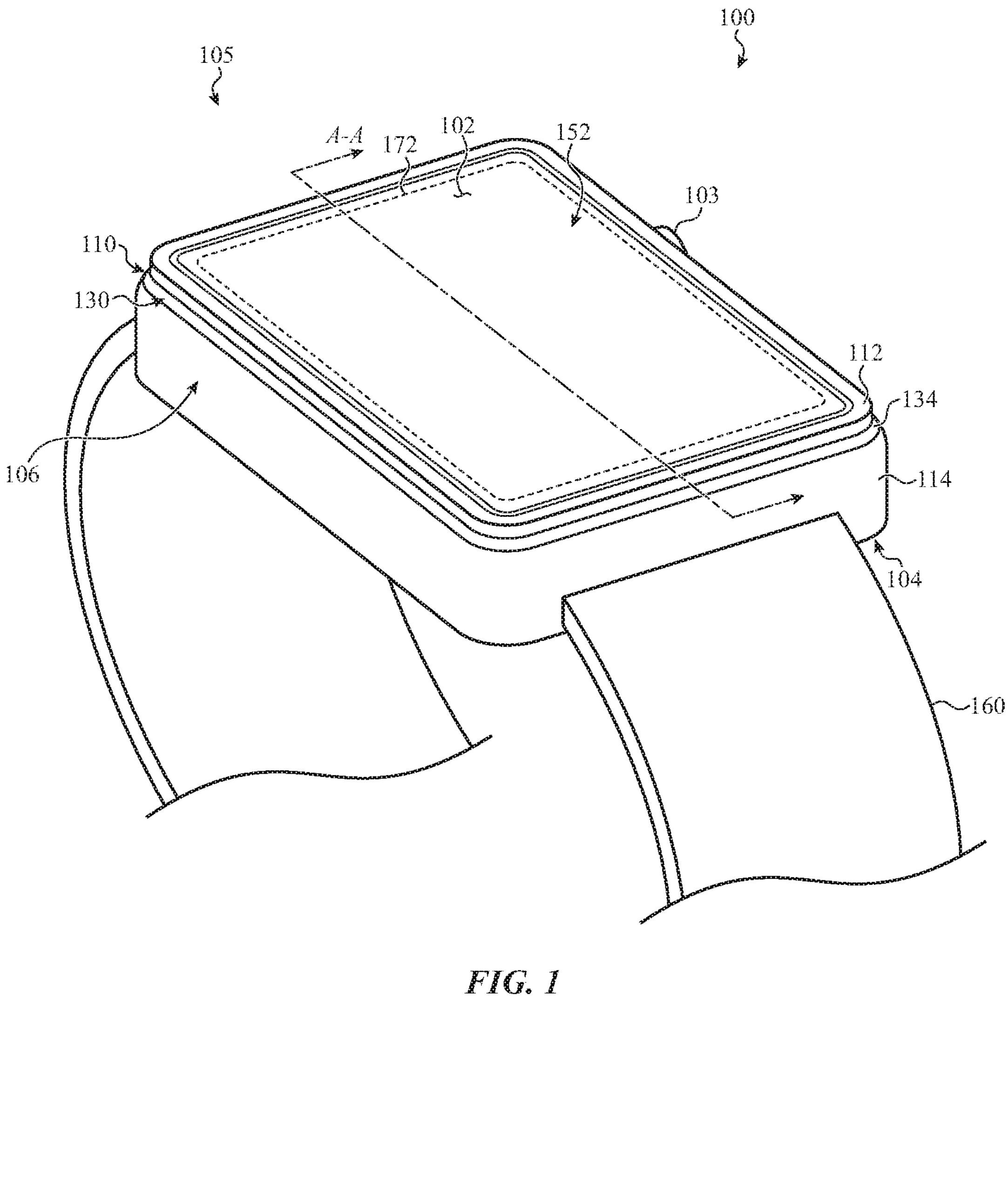

FIG. 1

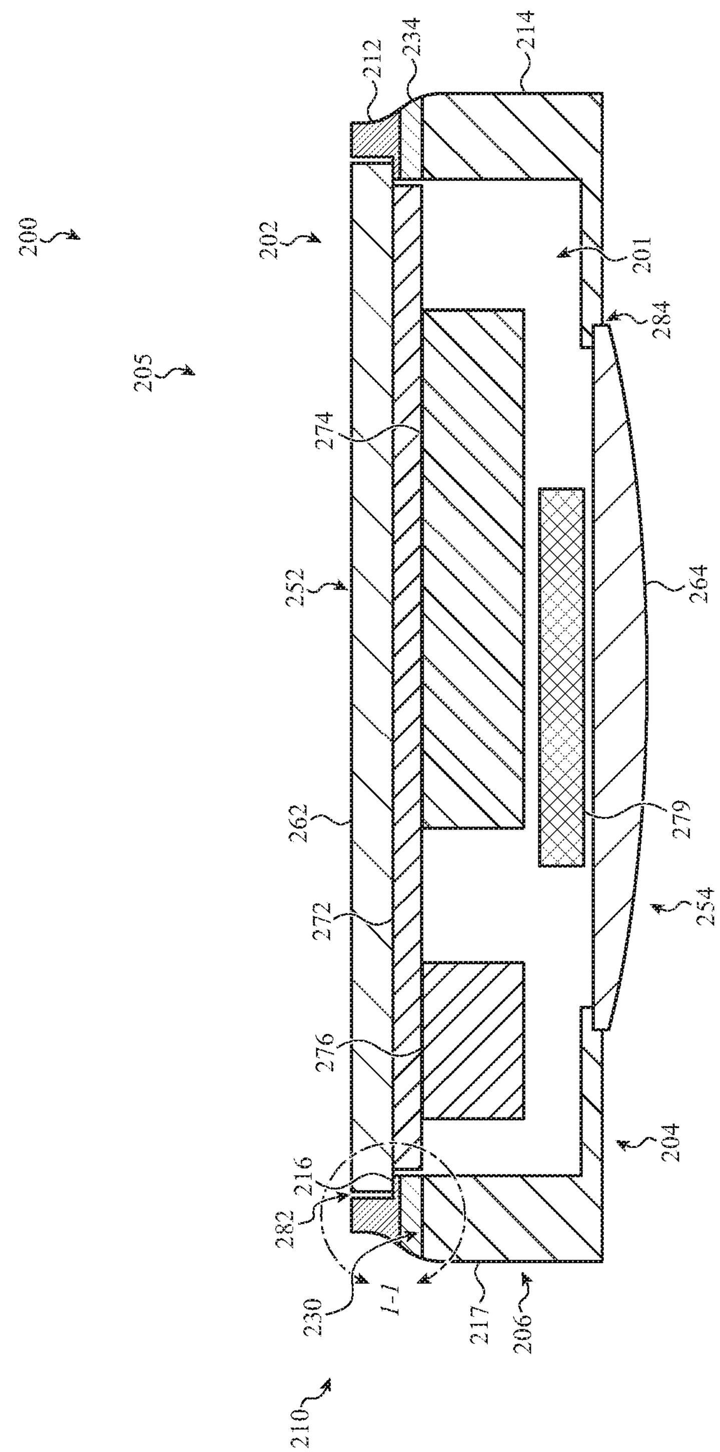
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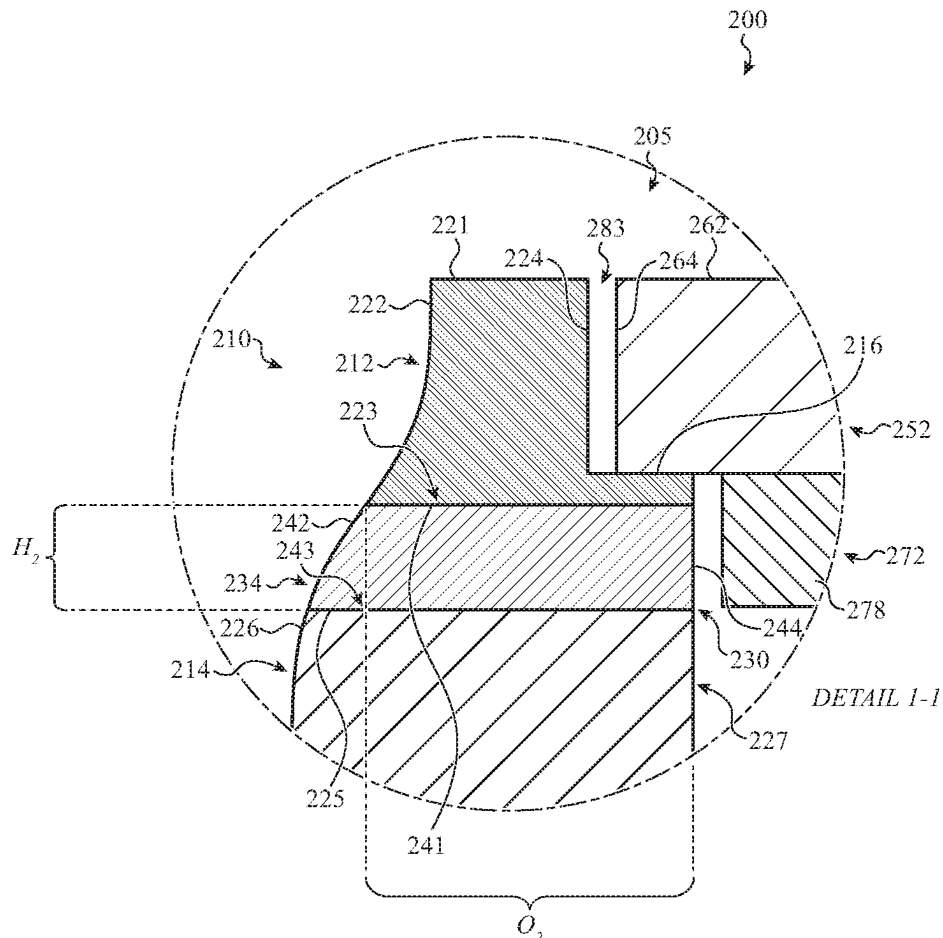
FIG. 2A



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DETAIL 1-1
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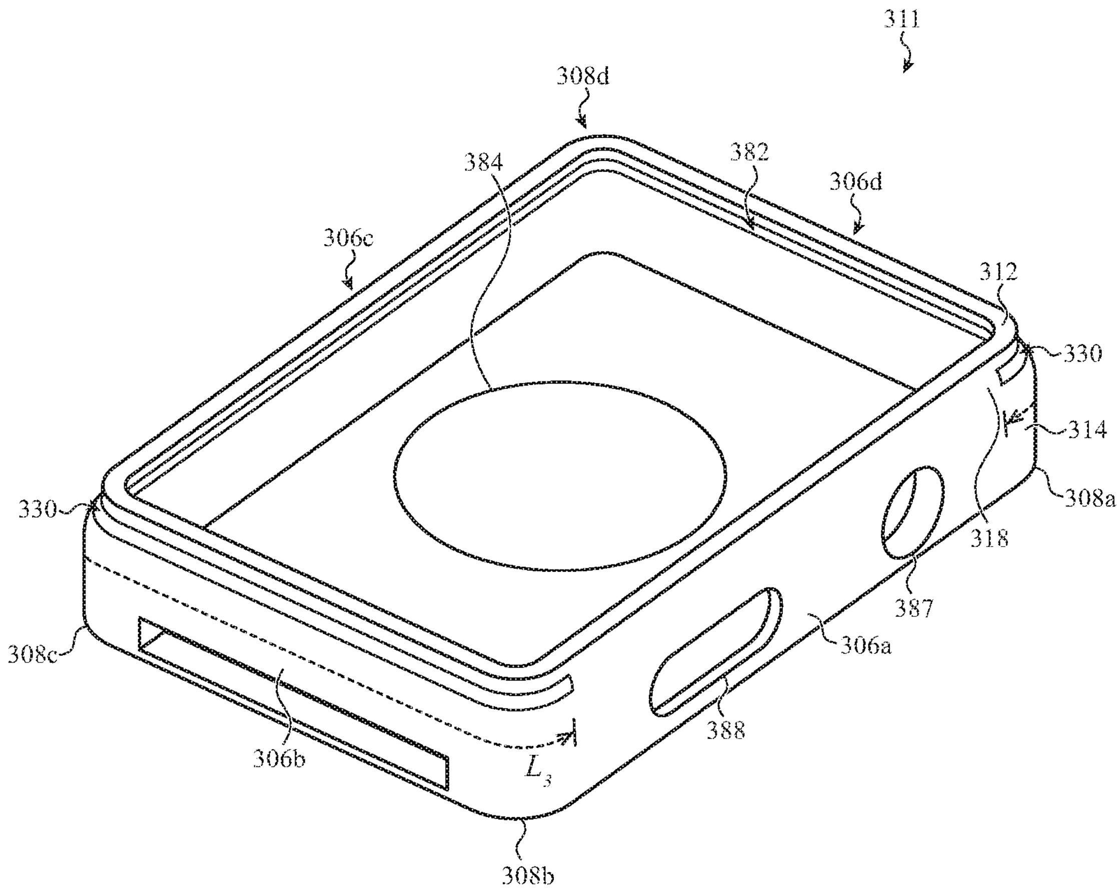
FIG. 2B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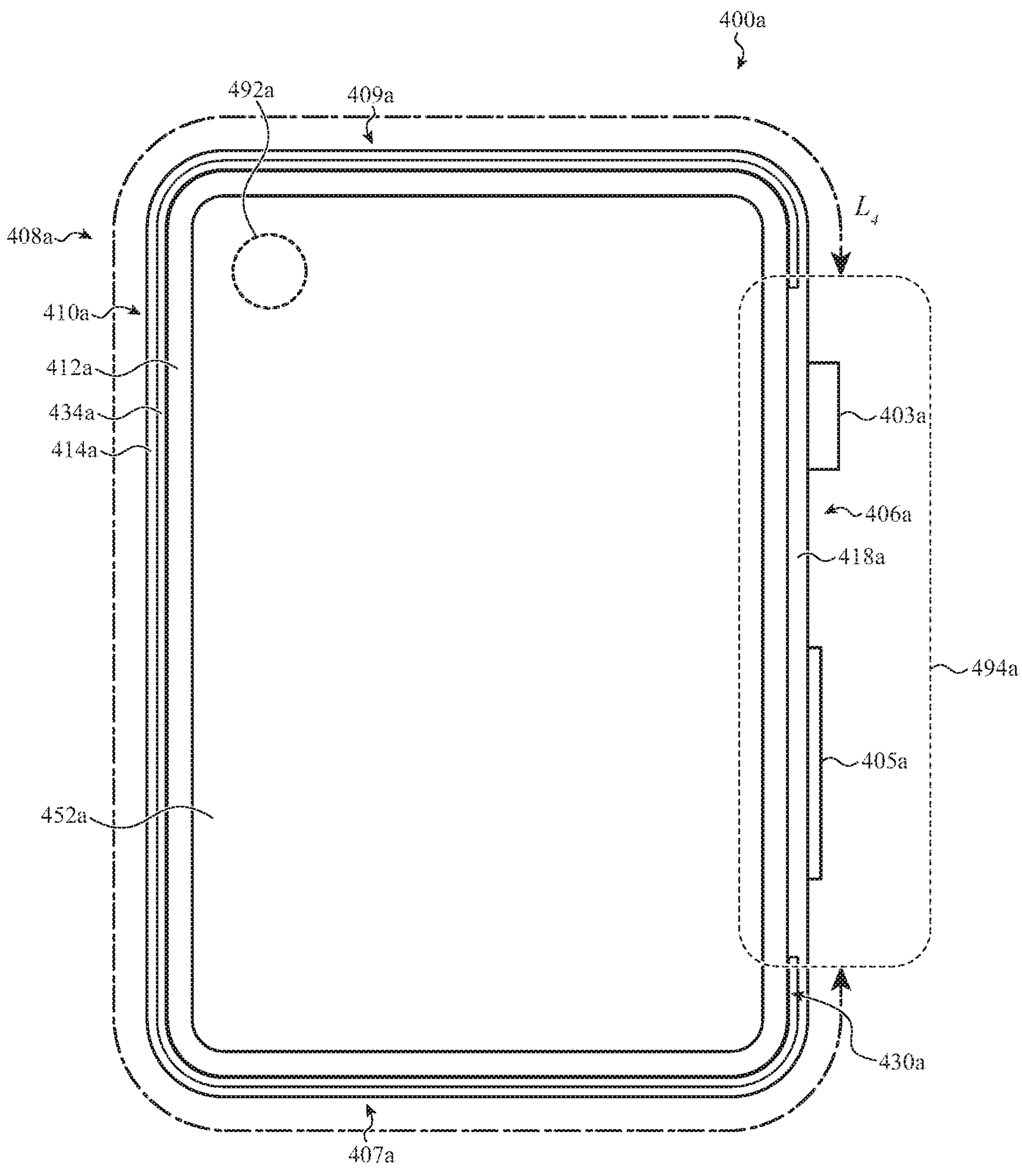
308b

FIG. 3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494a
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430a
407a

FIG. 4A

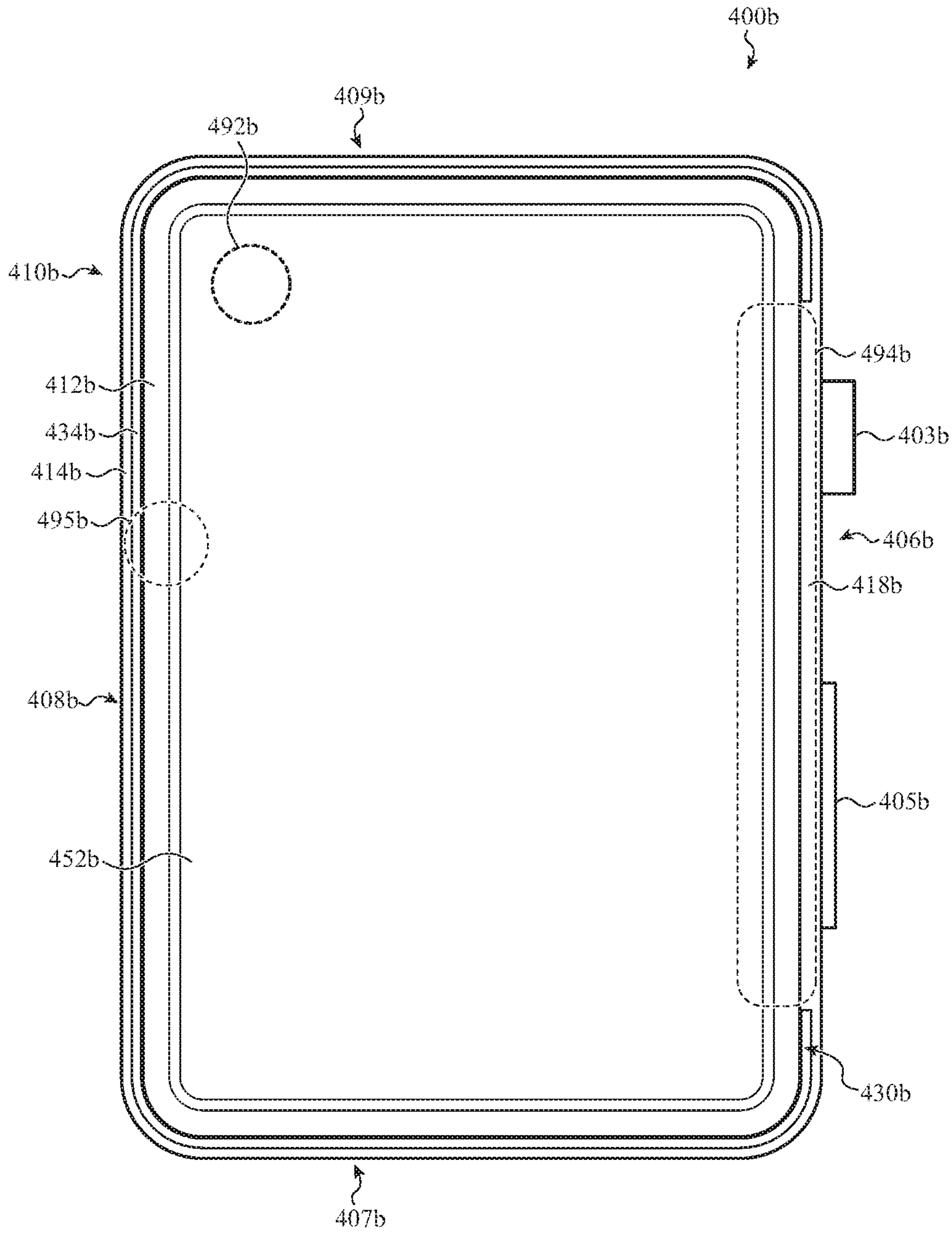
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FIG. 4B

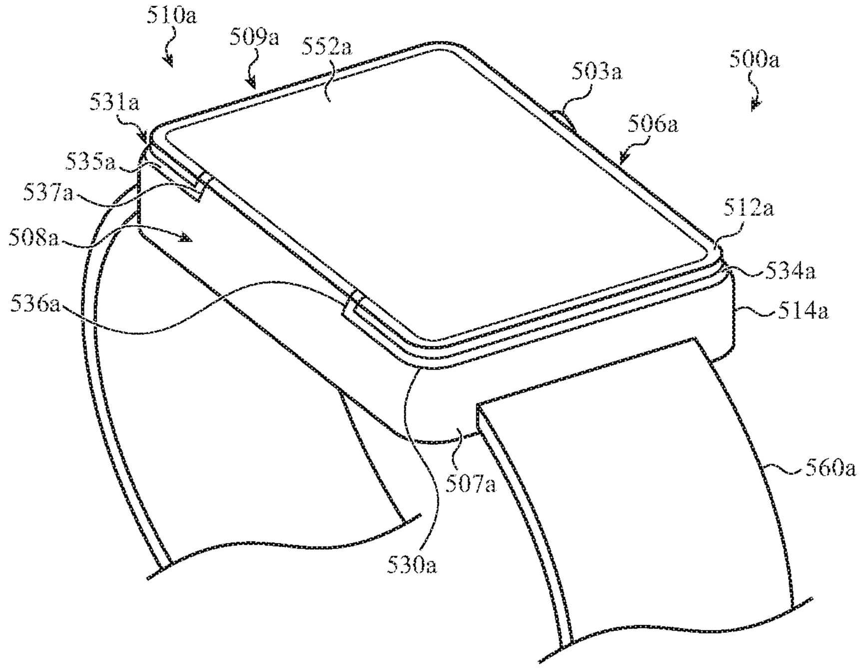
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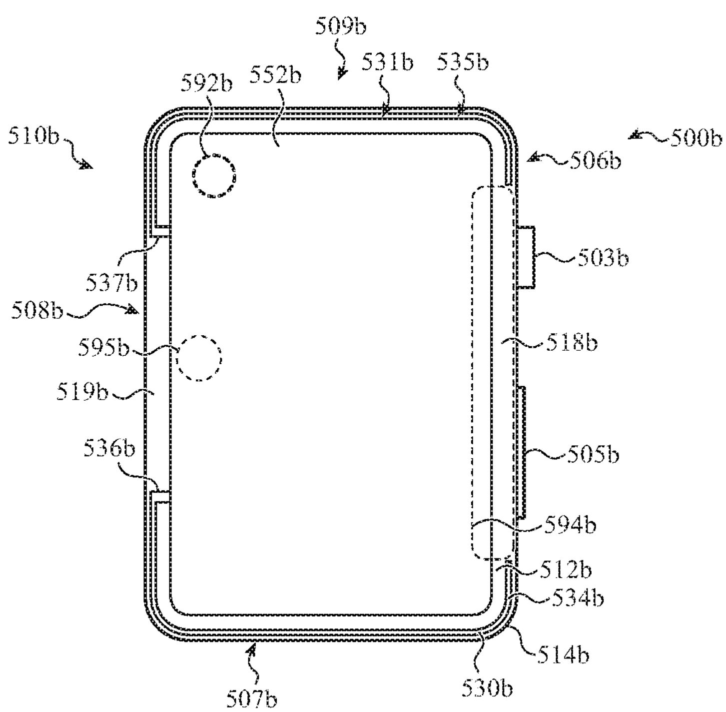
FIG. 5A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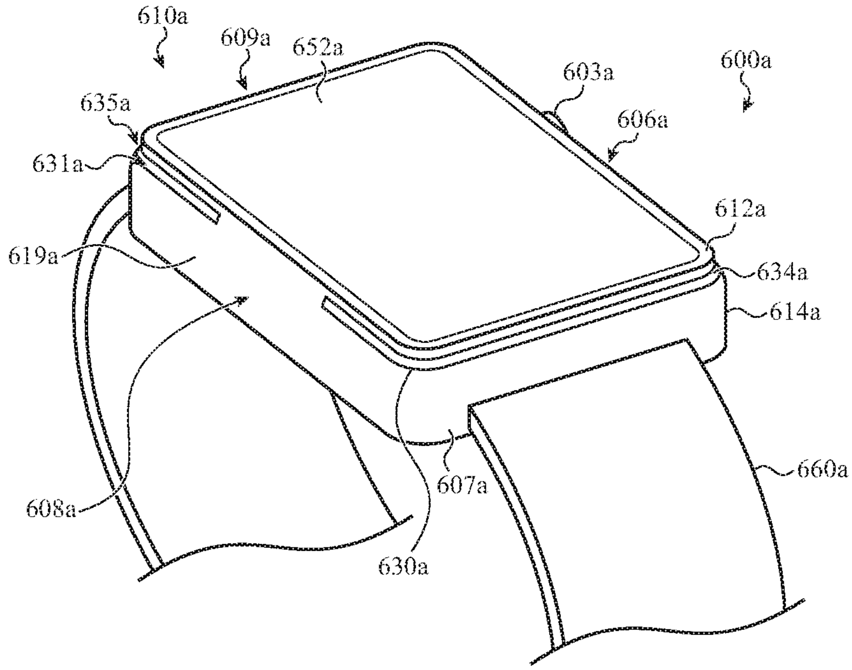
512b
534b
514b
507b
530b

FIG. 5B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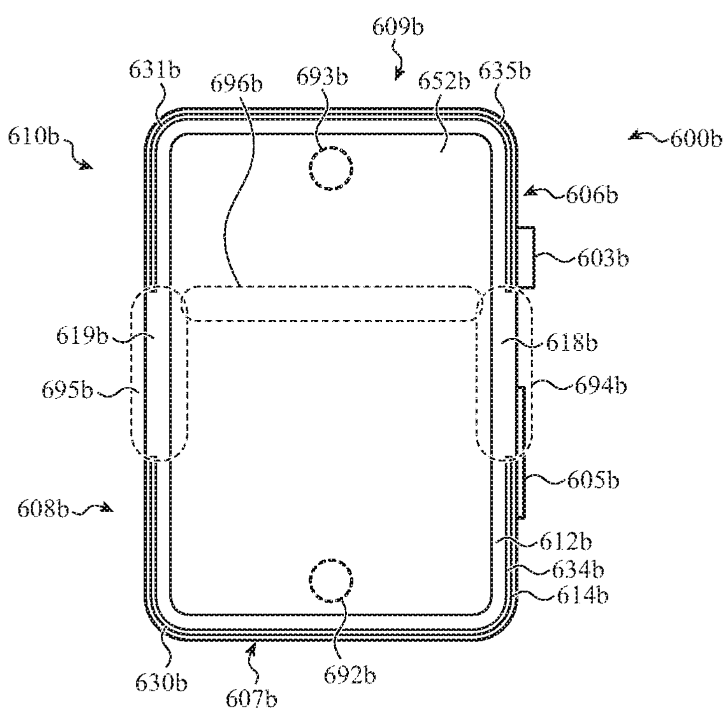
607a
630a

FIG. 6A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693b
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608b
612b
634b
614b
630b
607b
692b

FIG. 6B

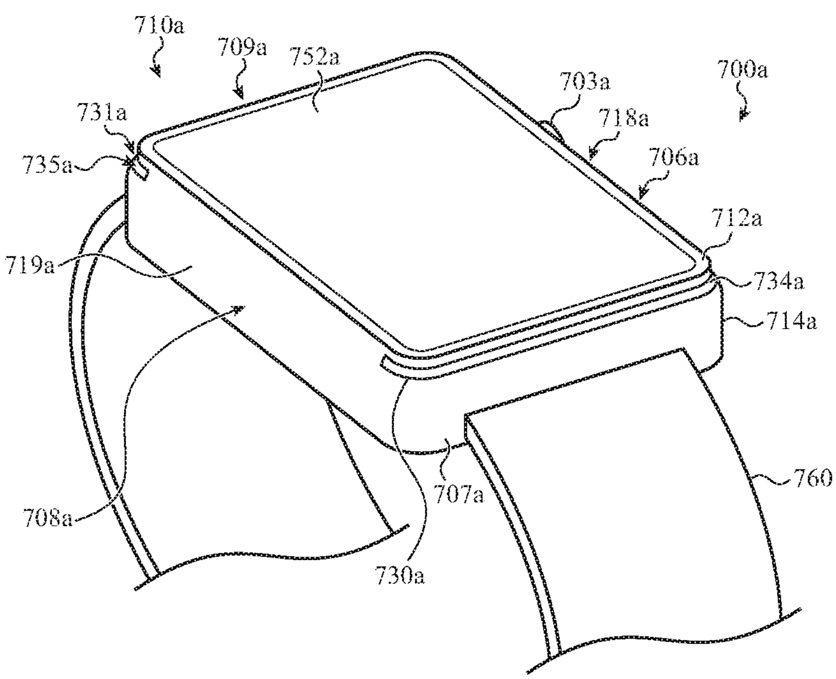
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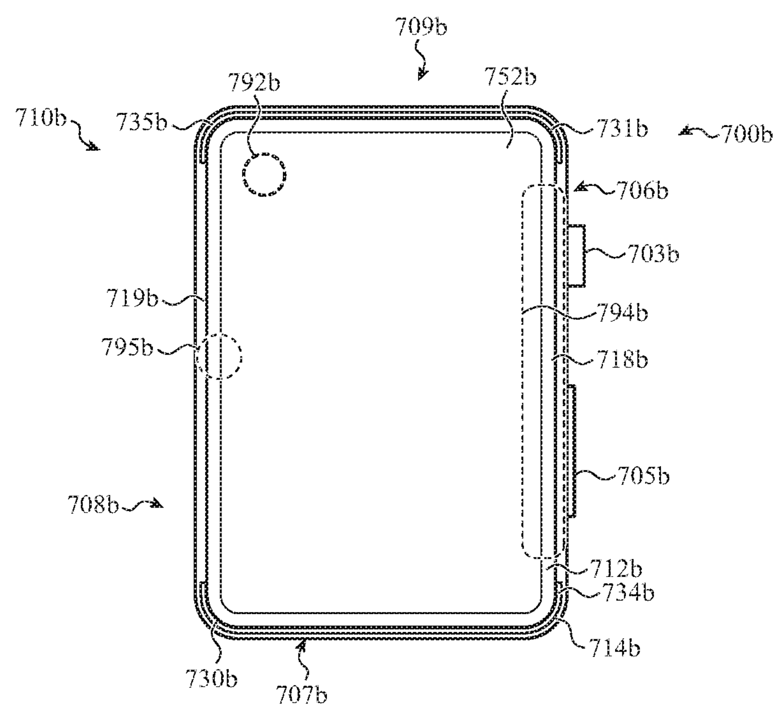
FIG. 7A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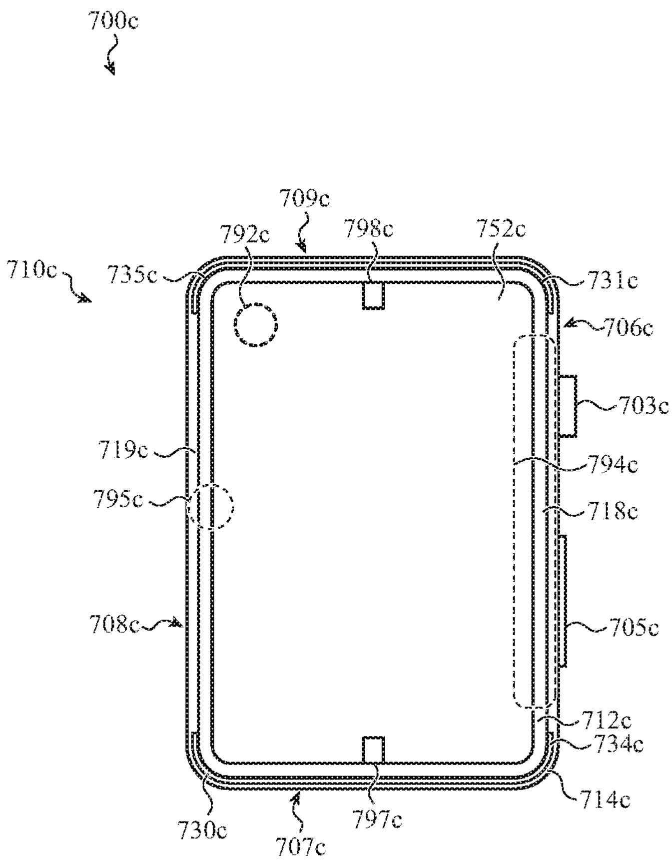
734b
714b
730b
707b

FIG. 7B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712c
734c
714c
730c
797c
707c

FIG. 7C

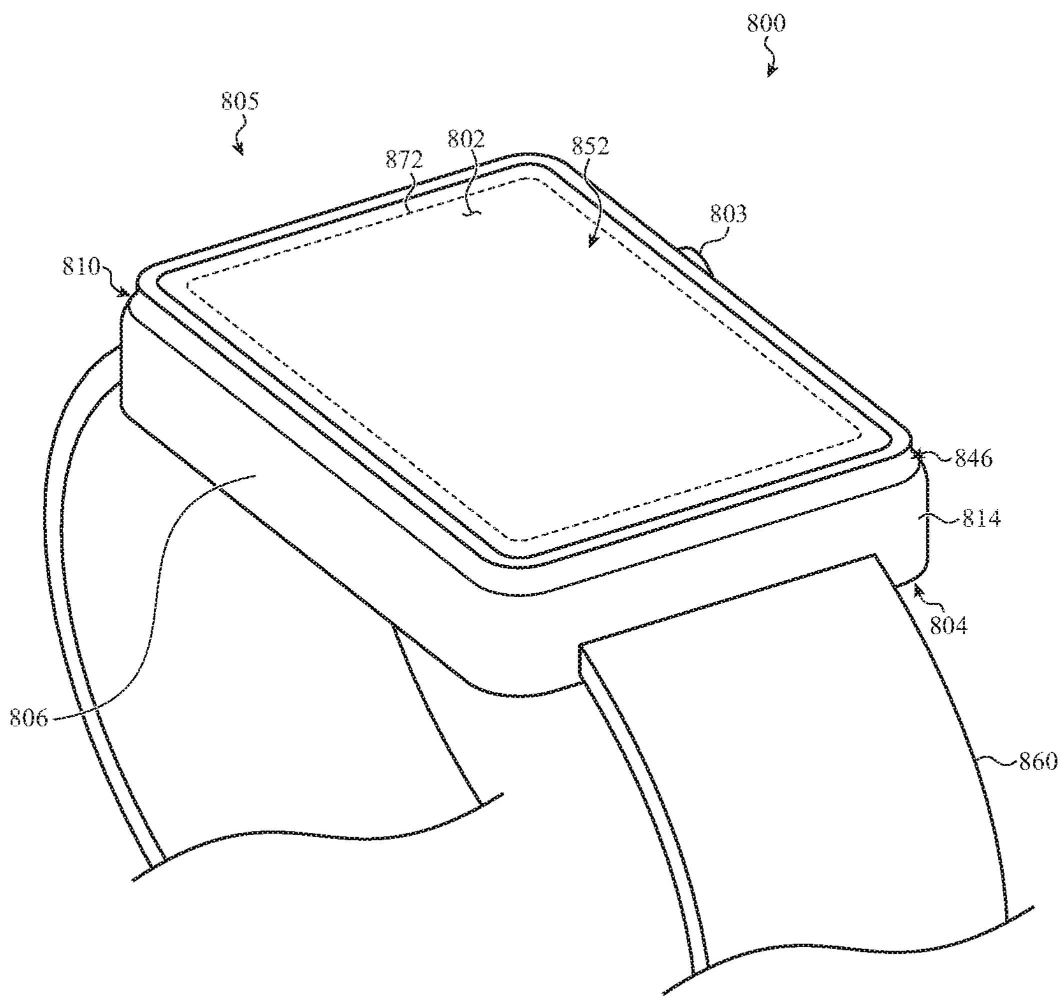

FIG. 8

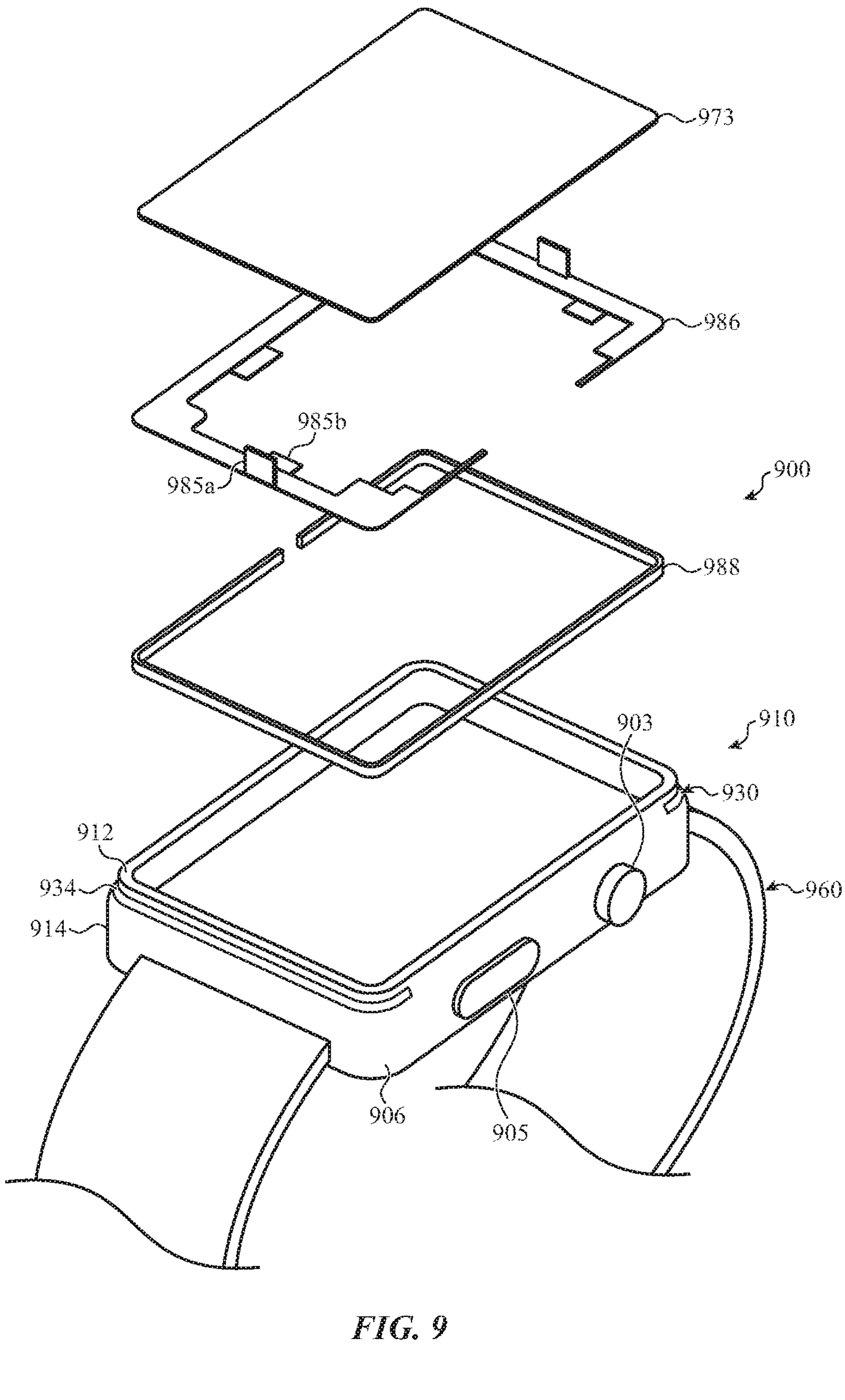

FIG. 9

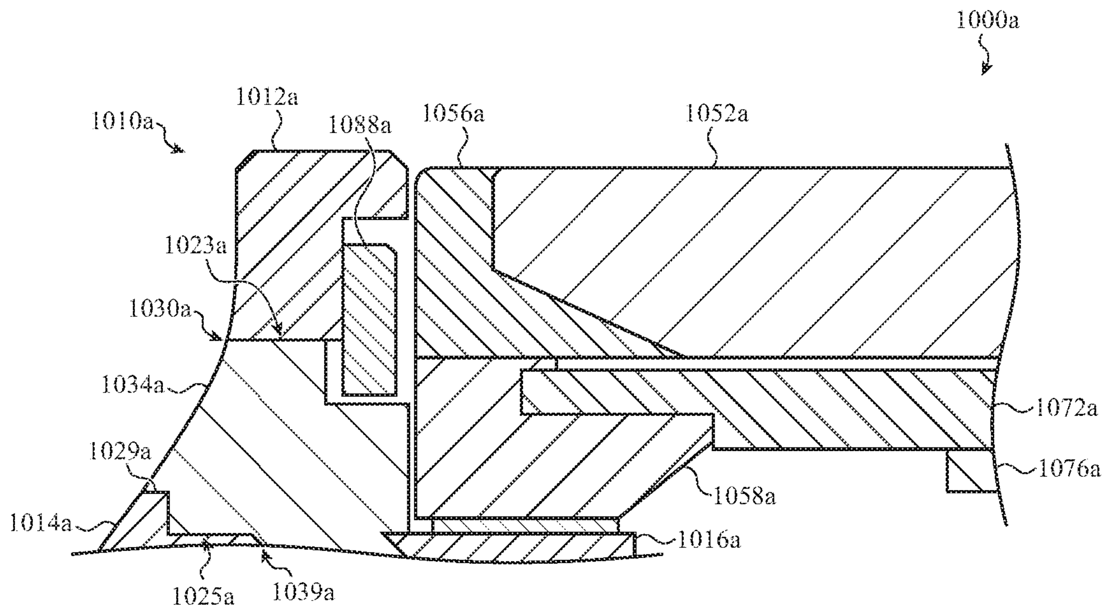

FIG. 10A

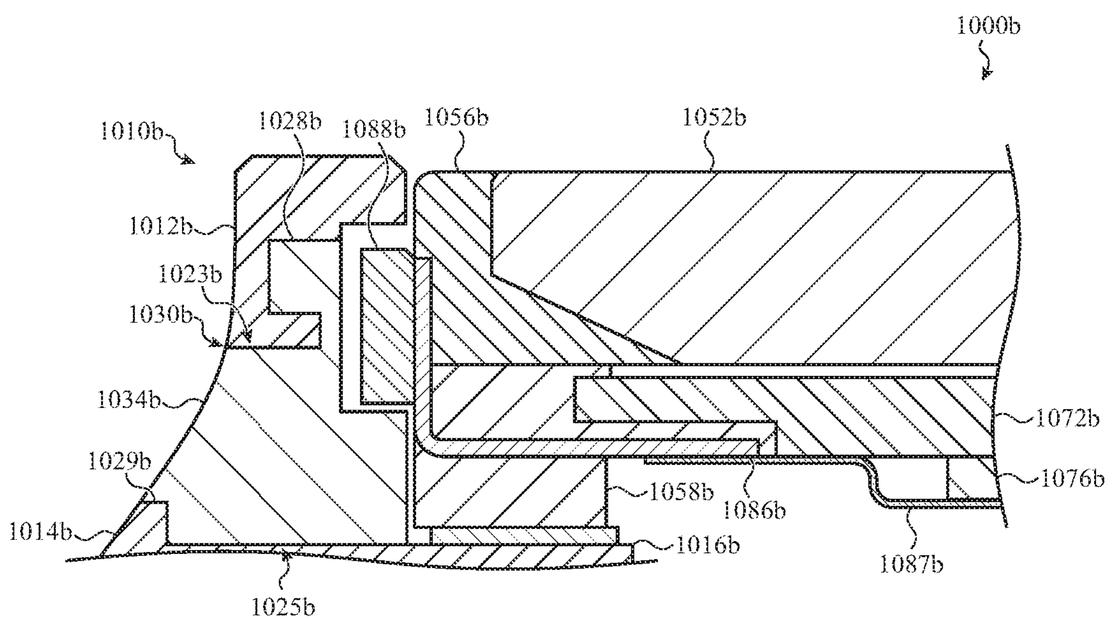

FIG. 10B

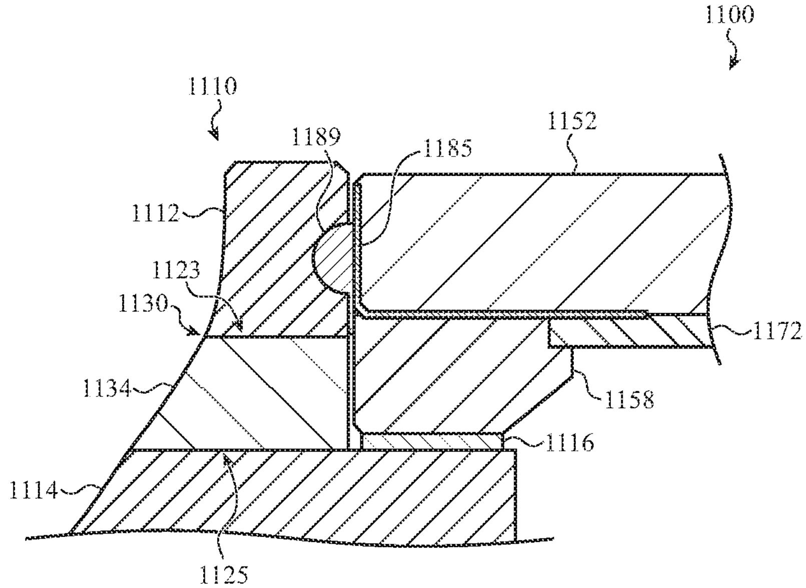
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FIG. 11

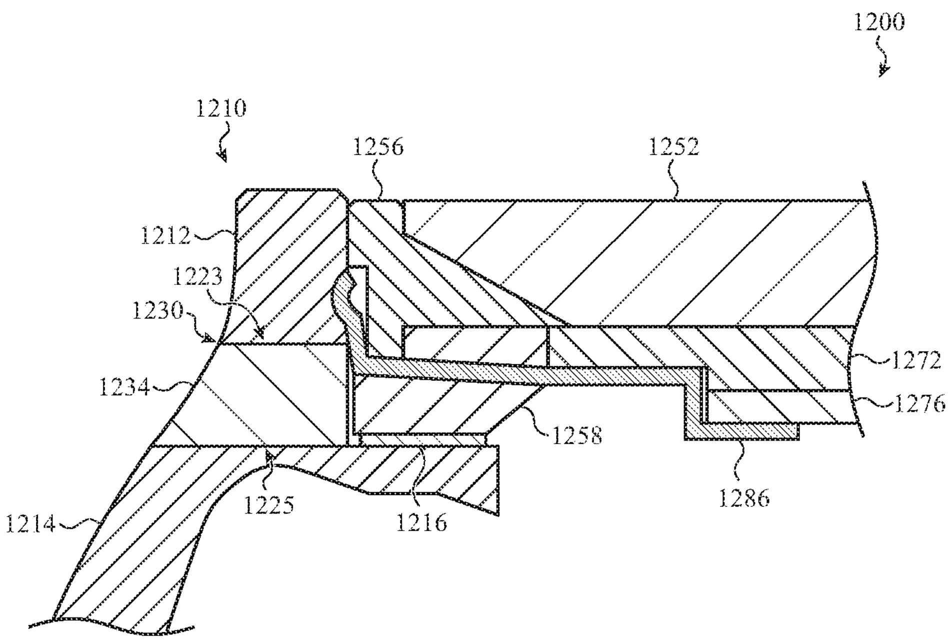
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FIG. 12

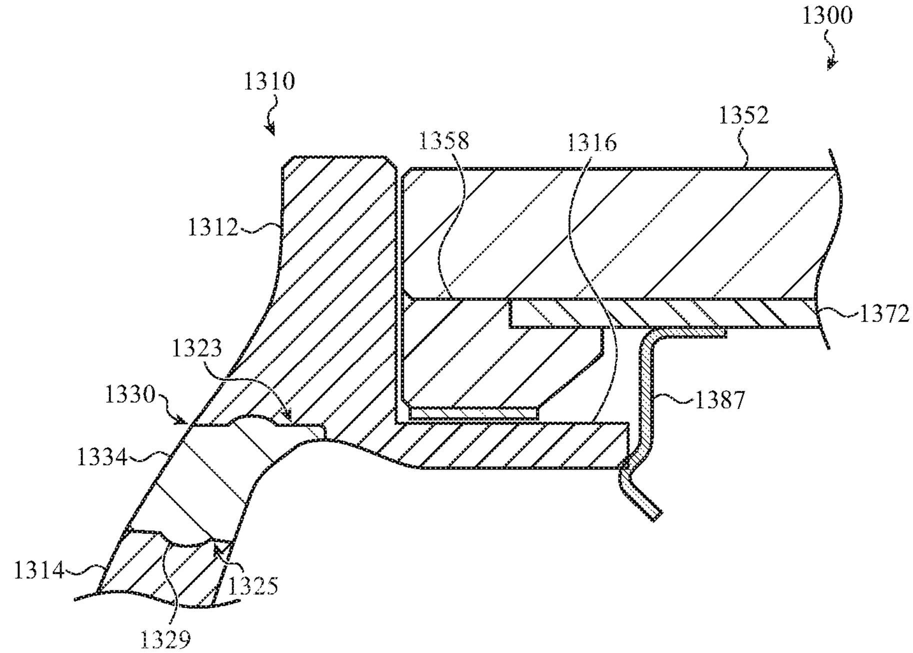
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FIG. 13

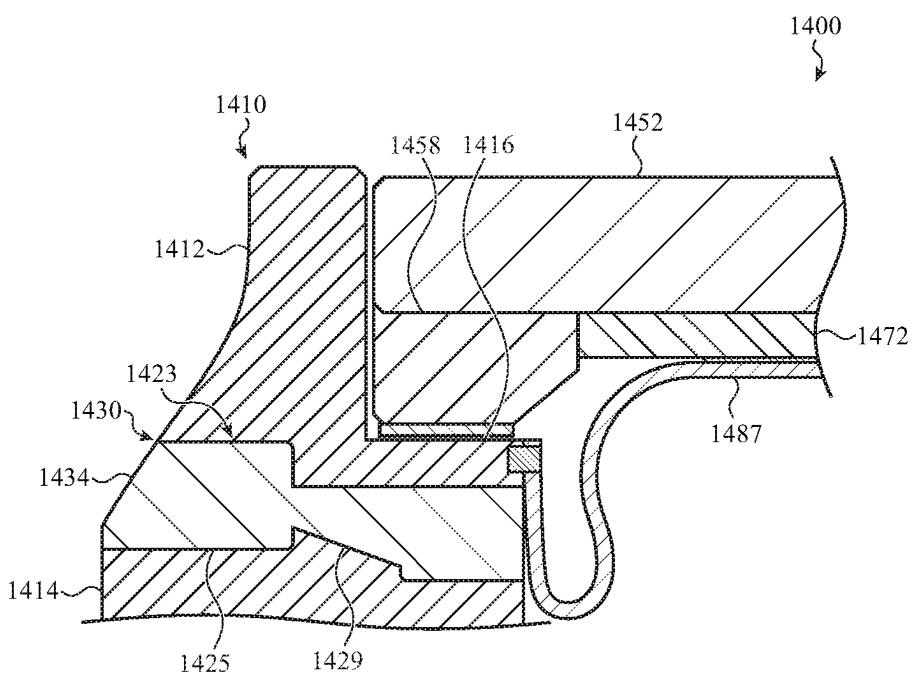
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FIG. 14

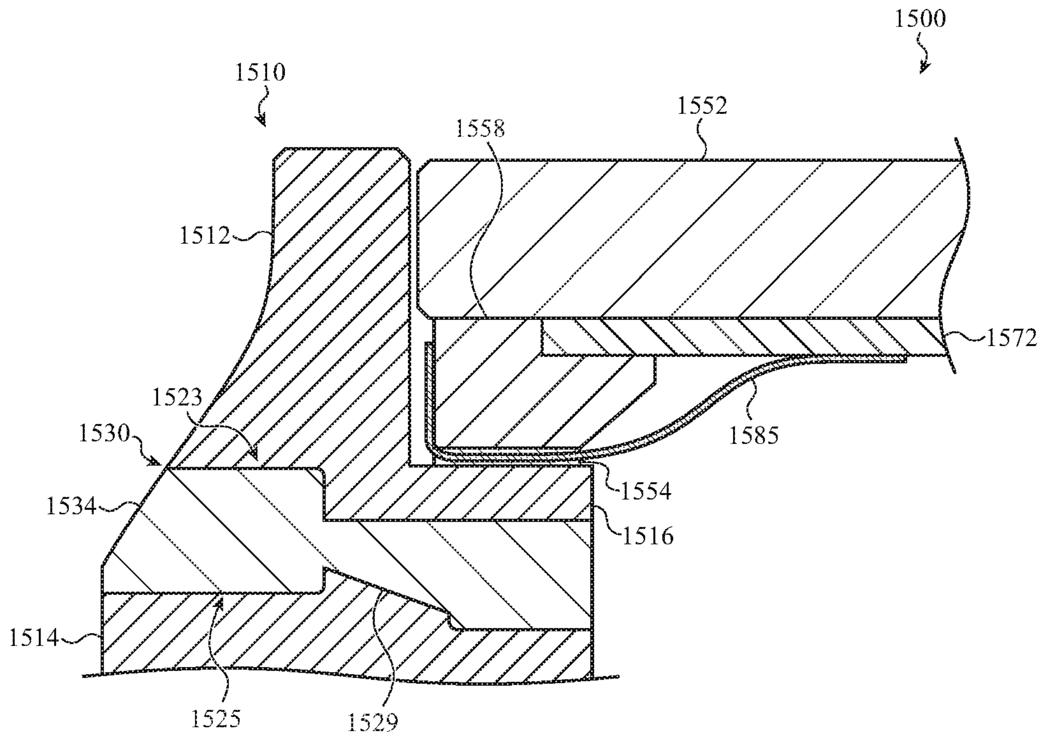
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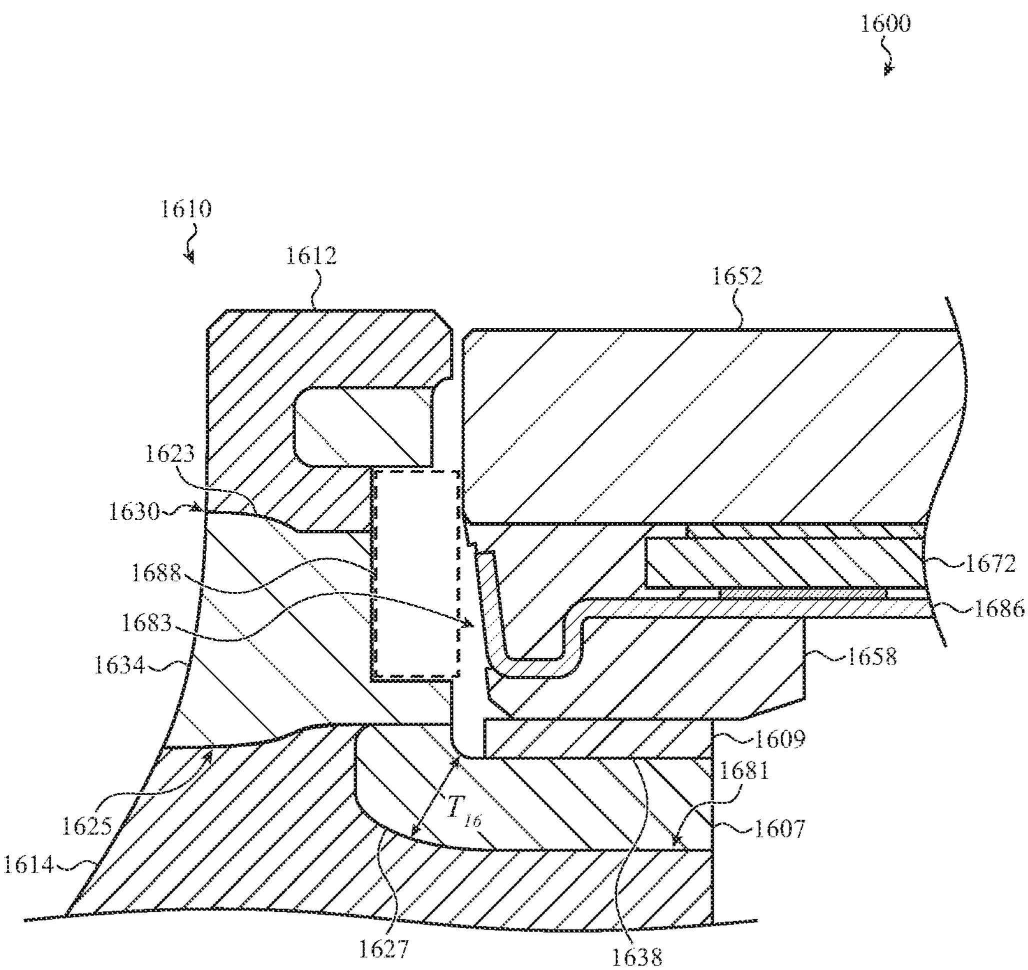
FIG. 15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T_{16}
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FIG. 16

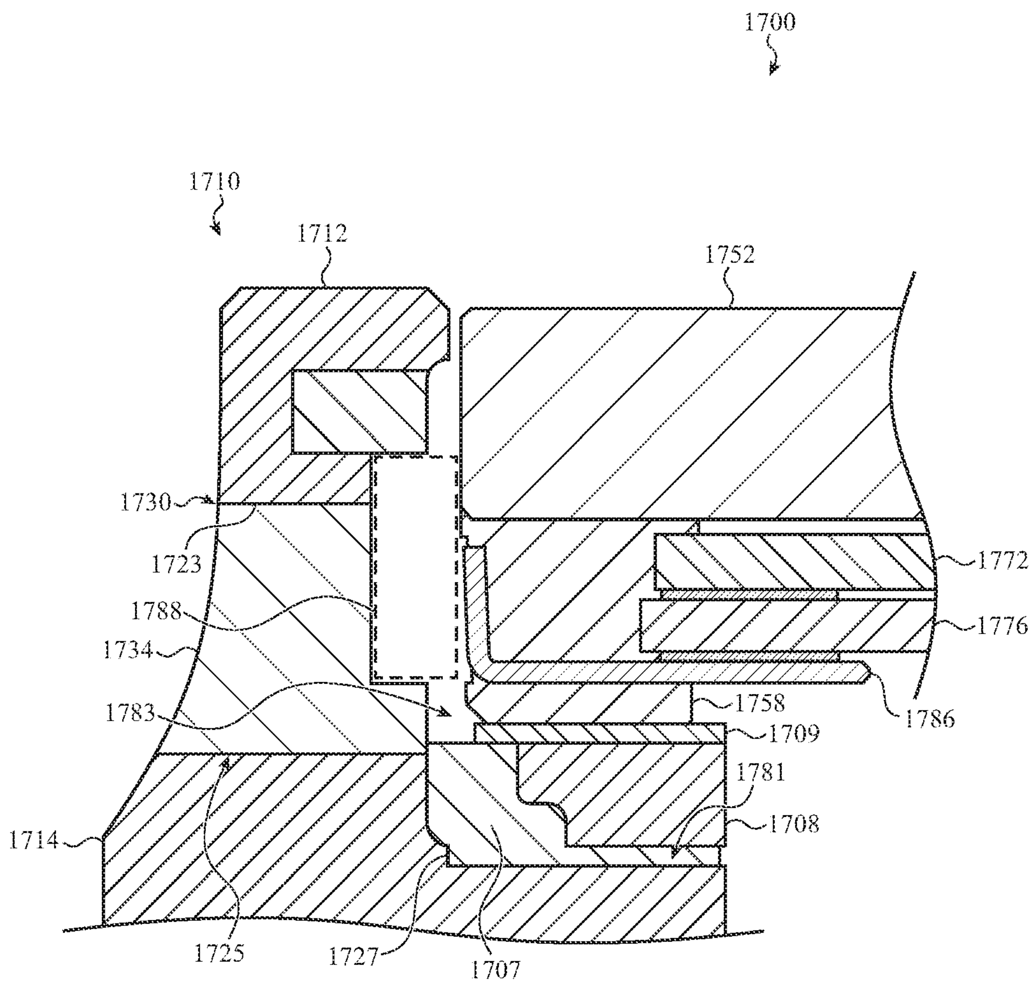
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FIG. 17

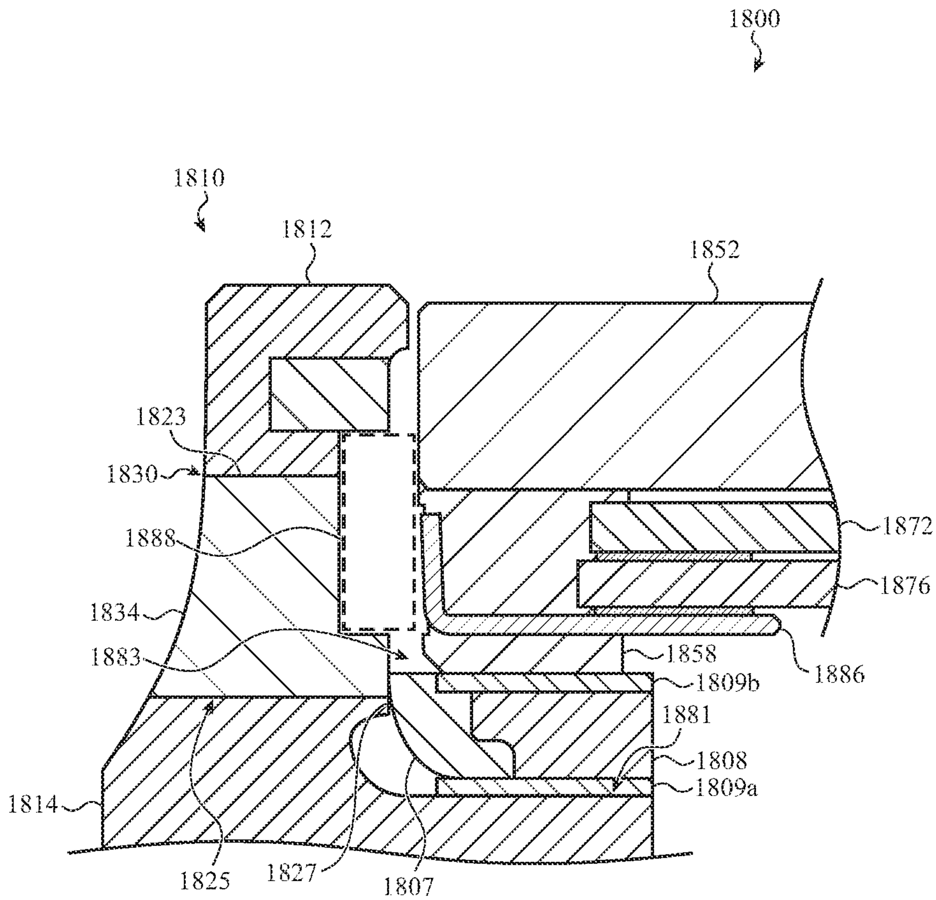
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FIG. 18

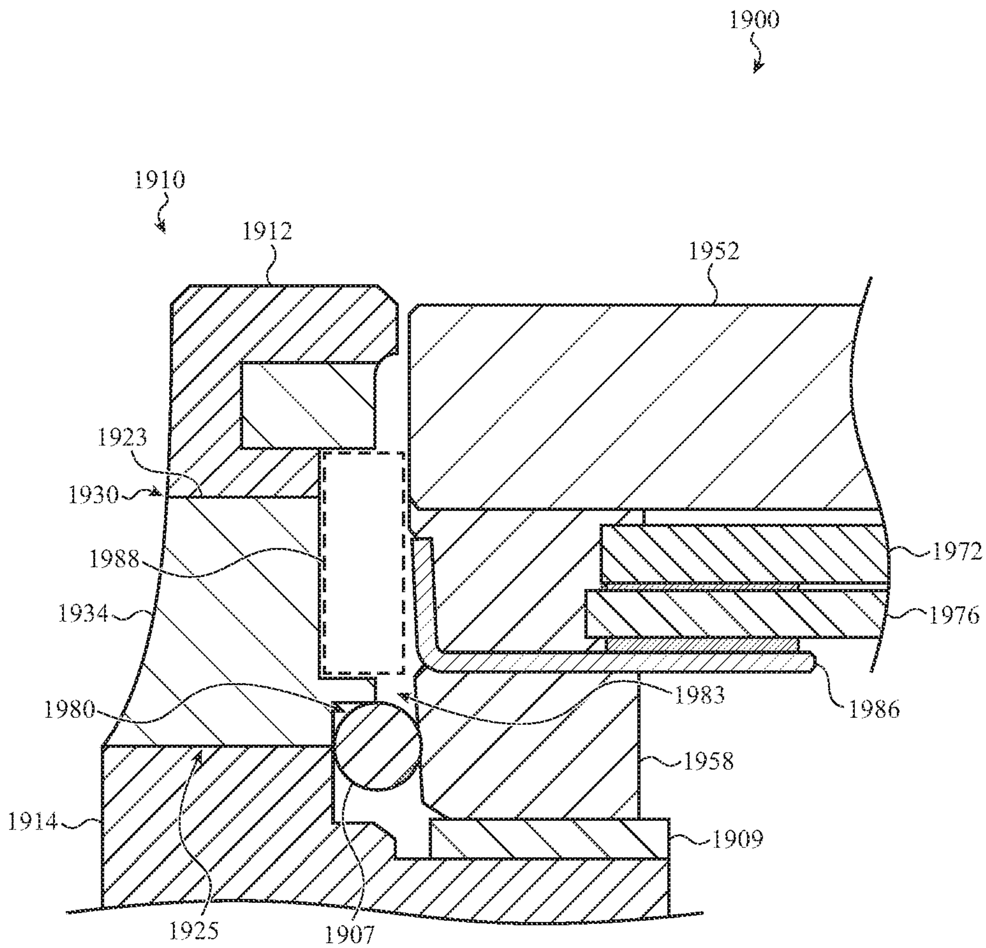
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FIG. 19

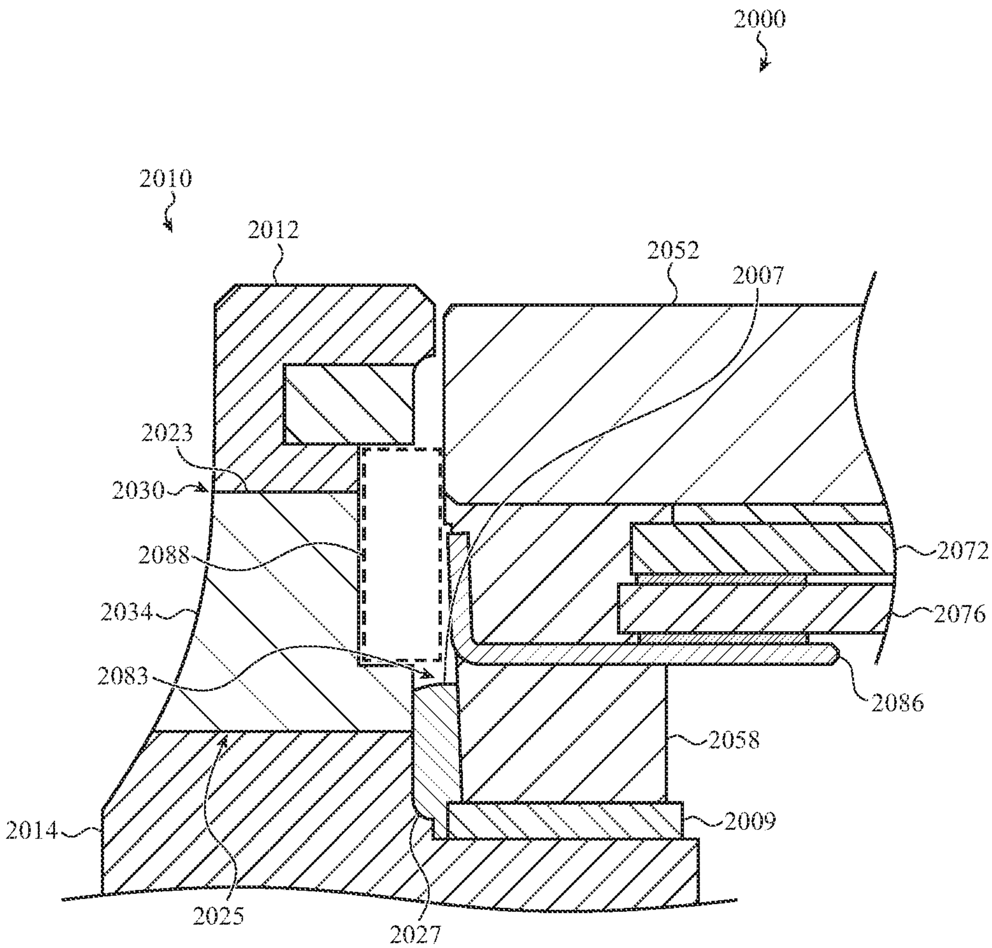
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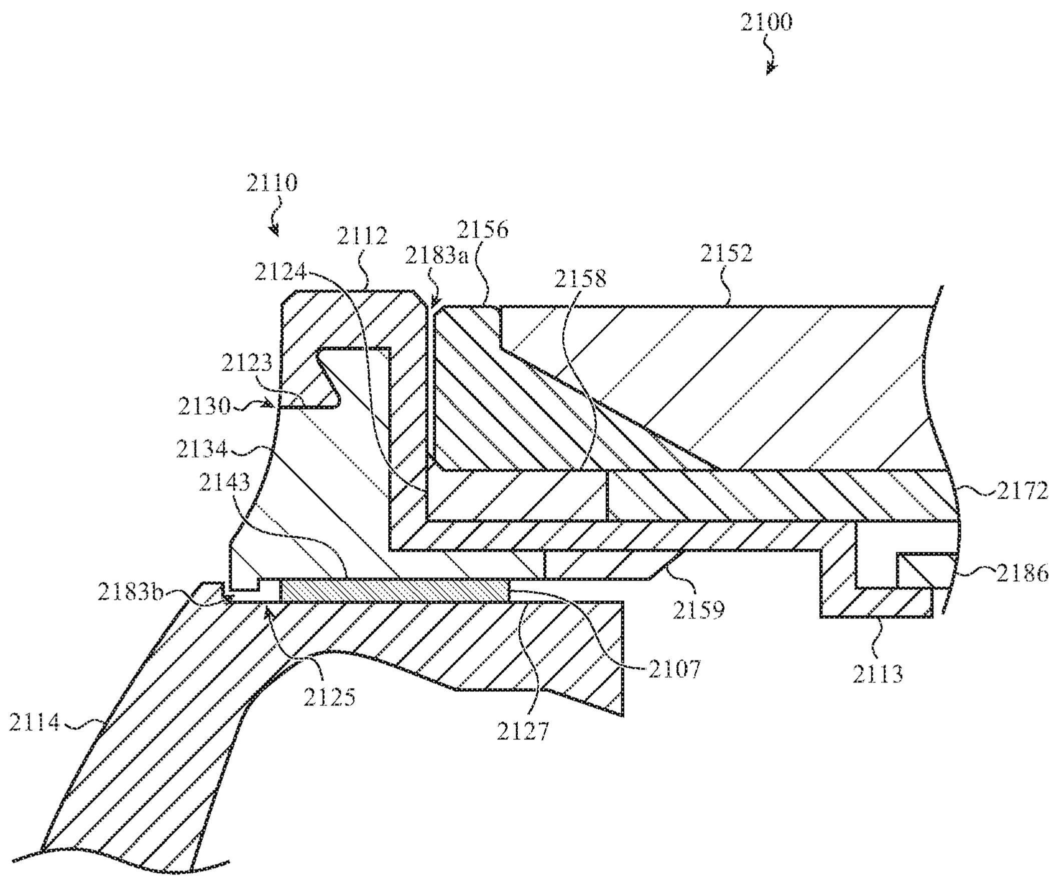
FIG. 20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2127

FIG. 21

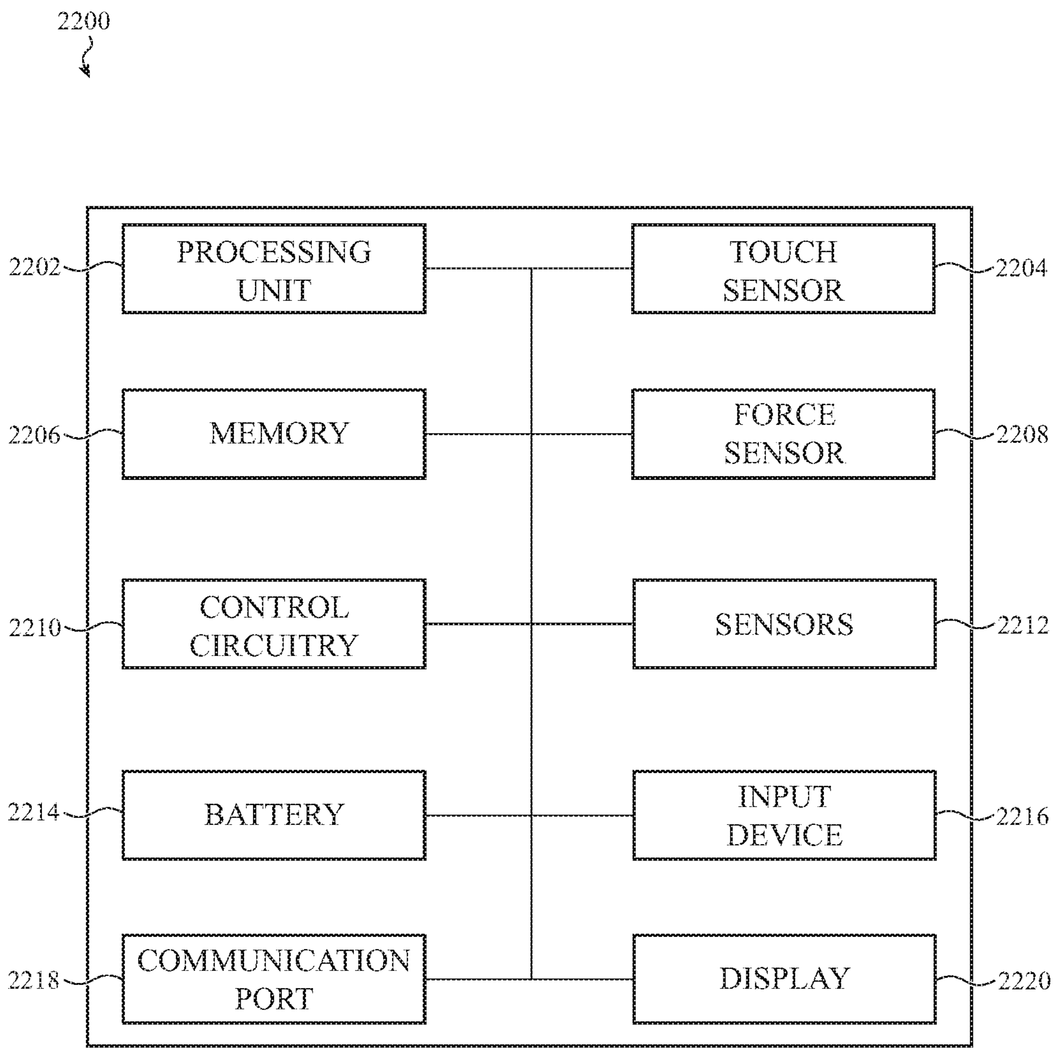
2200
2202
PROCESSING UNIT
TOUCH SENSOR
2204
2206
MEMORY
FORCE SENSOR
2208
2210
CONTROL CIRCUITRY
SENSORS
2212
2214
BATTERY
INPUT DEVICE
2216
2218
COMMUNICATION PORT
DISPLAY
2220

FIG. 22

PORTABLE ELECTRONIC DEVICE HAVING INTEGRATED ANTENNA ELEMENTS

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is a nonprovisional application of and claims the benefit of U.S. Provisional Patent Application No. 63/247,674, filed Sep. 23, 2021 and titled "Portable Electronic Device Having Integrated Antenna Elements," and U.S. Provisional Patent Application No. 63/344,473, filed May 20, 2022 and titled "Portable Electronic Device Having Integrated Antenna Elements," the disclosures of which are hereby incorporated herein by reference in their entireties.

FIELD

The described embodiments relate generally to housings for electronic devices and electronic devices including the housings. More particularly, the present embodiments relate to an electronic device including an antenna element within a display assembly which is operatively coupled to a conductive upper portion of the housing.

BACKGROUND

Some electronic devices include internal antennas and other electronics that can be used to conduct wireless communication. When the electronic device includes an antenna inside a housing that is formed from a metal material, the conductive nature of the metal material may interfere with signal transmission from the antenna.

The systems and techniques described herein are directed to electronic devices that include a conductive housing that is configured to facilitate operation of an antenna.

SUMMARY

Some embodiments are directed to an electronic device having a wireless communication system that includes an antenna element within the display assembly and an antenna element defined by the housing. Each of these antenna elements may be a resonating antenna element. The two resonating antenna elements may be operably coupled during operation of the wireless communication system. Such a wireless communication system may be particularly useful for electronic devices having relatively small housings, such as wearable electronic devices.

In embodiments, the housing defines an upper conductive portion, a lower conductive portion, and a slot positioned between the upper and lower portions. The housing may further include a dielectric portion positioned within the slot. The upper conductive portion defines a resonating antenna element of the housing. In some cases, the two resonating antenna elements may be operably coupled by conductively coupling the upper conductive portion of the housing to the resonating antenna element of the display.

In some embodiments, the slot (with the dielectric portion) may be configured to operate as a radiating element of the wireless communication system. In some cases, the slot is oriented so that a long direction of the slot extends across at least one side of the housing. In additional cases, the long direction of the slot extends across two more sides of the housing.

The wireless communication system includes a feed and a ground. In embodiments, the feed is coupled to at least one of the resonating antenna element of the display or the resonating antenna element of the housing, which is the upper conductive portion of the housing. The feed may be coupled to one or more of a transmitter, a receiver, or a transceiver. The ground may be coupled to the lower conductive portion of the housing.

The disclosure provides an electronic device comprising a display assembly comprising a first antenna element of a wireless communication system, a cover positioned over the display assembly, and a housing. The housing defines an upper conductive portion, the upper conductive portion defining a second antenna element of the wireless communication system, the second antenna element operably coupled to the first antenna element, a lower conductive portion, a slot defined between the upper conductive portion and the lower conductive portion of the housing, and a dielectric portion positioned at least partly within the slot.

The disclosure also provides an electronic device comprising a display assembly comprising a display component and a first antenna element, a front cover positioned over the display assembly, and a housing. The housing comprises a housing member formed from a conductive material, the housing member defining an upper portion at least partly surrounding the front cover and defining a second antenna element and a lower portion. The housing further comprises a dielectric member positioned at least partially within a slot defined between the upper portion and the lower portion. The electronic device further comprises a wireless communication circuit operably coupled to the first antenna element and the second antenna element and configured to transmit wireless signals along a region of the housing including the slot.

In addition, the disclosure provides an electronic device comprising a display assembly comprising a circuit assembly comprising a first antenna element of a wireless communication system, a housing, and a cover positioned over the display assembly. The housing defines an upper conductive portion defining a second antenna element of the wireless communication system, a lower conductive portion, a conductive bridge portion connecting the upper and the lower conductive portions, the conductive bridge portion, the upper conductive portion, and the lower conductive portion defining a slot. The housing further comprises a dielectric portion positioned at least partially within the slot.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like elements.

FIG. **1** shows a view of an example electronic device.

FIG. **2**A shows an example cross-sectional view of an electronic device.

FIG. **2**B shows a detail view of an electronic device.

FIG. **3** shows a view of an example conductive housing member.

FIGS. **4**A and **4**B show top views of example electronic devices.

FIG. **5**A shows a view of another example electronic device and FIG. **5**B shows an example top view of the electronic device of FIG. **5**A.

FIG. **6**A shows a view of another example electronic device and FIG. **6**B shows an example top view of the electronic device of FIG. **6**A.

FIG. **7**A shows a view of another example electronic device and FIGS. **7**B and **7**C shows example top views of the electronic device of FIG. **7**A.

FIG. **8** shows a view of another example electronic device.

FIG. **9** shows a partial exploded view of an example electronic device.

FIG. **10**A shows an example of a partial cross-sectional view of an electronic device.

FIG. **10**B shows another example of a partial cross-sectional view of an electronic device.

FIG. **11** shows another example of a partial cross-sectional view of an electronic device.

FIG. **12** shows another example of a partial cross-sectional view of an electronic device.

FIG. **13** shows another example of a partial cross-sectional view of an electronic device.

FIG. **14** shows another example of a partial cross-sectional view of an electronic device.

FIG. **15** shows another example of a partial cross-sectional view of an electronic device.

FIG. **16** shows another example of a partial cross-sectional view of an electronic device.

FIG. **17** shows another example of a partial cross-sectional view of an electronic device.

FIG. **18** shows another example of a partial cross-sectional view of an electronic device.

FIG. **19** shows another example of a partial cross-sectional view of an electronic device.

FIG. **20** shows another example of a partial cross-sectional view of an electronic device.

FIG. **21** shows another example of a partial cross-sectional view of an electronic device.

FIG. **22** shows a block diagram of a sample electronic device.

The use of cross-hatching or shading in the accompanying figures is generally provided to clarify the boundaries between adjacent elements and also to facilitate legibility of the figures. Accordingly, neither the presence nor the absence of cross-hatching or shading conveys or indicates any preference or requirement for particular materials, material properties, element proportions, element dimensions, commonalities of similarly illustrated elements, or any other characteristic, attribute, or property for any element illustrated in the accompanying figures.

Additionally, it should be understood that the proportions and dimensions (either relative or absolute) of the various features and elements (and collections and groupings thereof) and the boundaries, separations, and positional relationships presented therebetween, are provided in the accompanying figures merely to facilitate an understanding of the various embodiments described herein and, accordingly, may not necessarily be presented or illustrated to scale, and are not intended to indicate any preference or requirement for an illustrated embodiment to the exclusion of embodiments described with reference thereto.

DETAILED DESCRIPTION

Reference will now be made in detail to representative embodiments illustrated in the accompanying drawings. It should be understood that the following descriptions are not intended to limit the embodiments to one preferred implementation. To the contrary, the described embodiments are intended to cover alternatives, modifications, and equivalents as can be included within the spirit and scope of the disclosure and as defined by the appended claims.

Some embodiments are directed to an electronic device having a wireless communication system that includes an antenna element within the display assembly and an antenna element defined by the housing. Each of these antenna elements may be a resonating antenna element. The two resonating antenna elements may be operably coupled during operation of the wireless communication system. Such a wireless communication system may be particularly useful for electronic devices having relatively small housings, such as wearable electronic devices.

In embodiments, the housing defines an upper conductive portion, a lower conductive portion, and a slot positioned between the upper and lower portions. The housing may include a dielectric portion positioned within the slot. The upper conductive portion defines a resonating antenna element of the device. The upper portion may also define a top surface of the housing and may at least partially surround a side surface of a cover positioned over the display assembly. The lower portion may define a bottom surface of the housing and may define one or more openings, which may accommodate input members such as a button and/or a dial.

In some embodiments, the opening or slot (filled with the dielectric portion) may be configured to operate as a radiating element of the wireless communication system. In some cases, the slot is oriented so that a long direction of the slot extends across at least one side of the housing. In additional cases, the long direction of the slot extends across two more sides of the housing.

The display assembly may be disposed within an internal cavity defined by the housing. In some cases, the two resonating antenna elements may be operably coupled by conductively coupling the upper conductive portion of the housing to the resonating antenna element of the display. In some cases, the display assembly includes a display component and a circuit assembly, and the circuit assembly includes the resonating antenna element of the display. When the resonating antenna element of the display is included in a circuit assembly, the circuit assembly may be conductively coupled to the resonating antenna element of the housing. If desired, an electrically insulating element may be included in the electronic device to maintain antenna performance as discussed in more detail with respect to FIGS. **1**, **2**B, and **16**-**21**.

The wireless communication system includes a wireless communication circuit. A feed and a ground of the wireless communication system may be coupled to the wireless communication circuit. In embodiments, the feed is coupled to at least one of the resonating antenna element of the display or the resonating antenna element of the housing, which is the upper conductive portion of the housing. The feed may be coupled to one or more of a transmitter, a receiver, or a transceiver. The ground is coupled to the lower conductive portion of the housing.

The electronic devices described herein can provide several advantages. For example, the electronic devices described herein do not rely on a substantial gap between the housing and a display assembly for operation of the wireless communication system. The size of the display can therefore be enlarged when this gap is reduced. As an additional example, forming a radiating element in the housing can provide a radiating element having a length that can extend around a substantial portion of the periphery of the housing. When the electronic device has a relatively small housing, this radiating element can have a length suitable for frequency signals on the order of 1 GHz.

In some embodiments, the electronic device may be configured to maintain the performance of the electronic device when the device is submerged or subjected to wet environmental conditions. In some cases, ingress of a conducting fluid like water into a gap (alternately, void) between an interior surface of the housing and one or more internal components of the device can change the electrical properties of one or more device systems, which may result in a change in a performance of a wireless communication system and/or a sensor system of the device. To help reduce the impact of moisture or liquid ingress, the electronic device may include an electrically insulating element configured to maintain dielectric insulation between internal and external components of the electronic device. As described in greater detail below, the electrically insulating element may maintain the operation of one or more antenna(s) of a wireless communication system by maintaining dielectric insulation between a conductive portion of the housing and an internal component of the wireless communication system that is operable coupled to the conductive portion of the housing. In additional examples, the electrically insulating element may maintain the operation of one or more sensor systems of the electronic device by maintaining dielectric insulation between a conductive portion of the housing and an internal component of the sensor system that is operably coupled to the conductive portion of the housing. In some cases, the conductive portion of the housing may form an electrode or a terminal for the sensor system. In some examples, the sensor system is a health monitoring or biosensor system that may be configured to measure a physical state or condition of a user at least in part through physical contact between a user and the electrode or terminal defined by the conductive portion of the housing. The sensor system may be an electrocardiogram (ECG) sensor system, a heart rate sensor system, a galvanic skin response system, a bioimpedance sensor system, or the like.

These and other embodiments are discussed below with reference to FIGS. **1-22**. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes only and should not be construed as limiting.

FIG. **1** shows a view of an example electronic device or simply "device" **100**. For the purposes of this disclosure, the device **100** may be a portable electronic device including, for example, a wearable electronic device (e.g., a watch or other wrist-worn device), a health monitor device, a mobile phone, a tablet computer, a portable computer, a portable music player, a portable terminal, a wireless charging device, a device accessory, or other portable or mobile device. In some cases, the electronic device **100** may be a watch sometimes referred to as an electronic watch or a smartwatch.

The electronic device **100** includes an enclosure **105**. The enclosure includes a housing **110** and a front cover **152**. The front cover **152** is positioned over a display assembly **172**. The enclosure may also include a rear cover, as shown in the cross-section view of FIG. **2**A and the rear cover may be positioned over a sensing panel. The device **100** defines an exterior including a front surface **102**, a rear surface **104**, and a side surface **106**. In the example of FIG. **1**, the device **100** has an exterior that defines four sides, each of which may define a side surface. The electronic device also includes an input device **103**, which may be a dial having an outer surface configured to receive a rotary input. A band **160** is attached to the housing **110** and configured to secure the electronic device **100** to a user.

In the example of FIG. **1**, the housing **110** includes an upper portion **112**, a lower portion **114**, and a dielectric portion **134**. In embodiments, each of the upper portion **112** and the lower portion **114** is conductive (and may also be referred to as an upper conductive portion **112** and a lower conductive portion **114**). For example, each of the upper portion **112** and the lower portion **114** may be formed of a conductive material. In some cases, the conductive material comprises one or more metals and, in some cases, may be an iron-based alloy (such as steel), a titanium-based alloy, an aluminum-based alloy, a magnesium-based alloy, or the like. In some examples, the upper portion **112** and the lower portion **114** may form a unitary housing member in combination with a bridge portion of the housing, as shown in the example of FIG. **3**. In these examples, the upper portion **112**, the lower portion **114**, and the bridge portion may be formed from a single piece of material.

The housing **110** defines a slot **130** between the upper portion **112** and the lower portion **114**. The slot **130** may also be referred to herein as an opening. The slot **130** is positioned on at least one side **106** of the electronic device and may therefore also be referred to as a side slot. As shown in FIG. **1**, the dielectric portion **134** of the housing **110** is positioned within the slot **130** and substantially fills the slot **130**. For reference, FIG. **3** shows an example of a conductive housing member **311** prior to filling the slot **330** with a dielectric material. The slot **130** of FIG. **1** is "closed" in the sense that the perimeter of the slot is surrounded on all sides by other portions of the housing.

The dielectric portion **134** of the housing **110** may be formed of a (solid) dielectric material such as a polymer, silica, a ceramic material such as zirconia, alumina and/or titanium dioxide, or a combination thereof (e.g., a composite of particles of silica and/or a ceramic in a polymer matrix). The additional description of suitable dielectric materials provided with respect to FIGS. **2**A and **2**B is applicable to FIG. **1** and is not repeated here. The dielectric portion **134** may be bonded to the upper portion **112** and the lower portion **114**. The bonding of the dielectric portion **134** to the upper portion **112** and the lower portion **114** may be enhanced by surface modification of and/or formation of one or more retention features (also referred to as interlock features) on the upper portion **112** and/or the lower portion **114** as described further with respect to FIGS. **10**A, **10**B, and **13-15**. Retention features may take a variety of forms, such as a protrusion, a depression or groove, a hole, an angled surface, a stepped surface, and the like. In some cases, a dielectric portion such as the dielectric portion **134** may extend around a retention feature and in some cases may encapsulate a retention feature.

In embodiments, the front cover **152** is substantially transparent or includes one or more substantially transparent portions over the display assembly **172**. For example, the transmission may be at least 80%, 85%, 90%, or 95% over a visible wavelength range (e.g., the visible spectrum). The front cover **152** may be formed of a glass, a glass ceramic, a ceramic (such as sapphire), or combinations thereof. In addition, the front cover **152** may be formed of one or more layers of a glass, a glass ceramic, a ceramic (such as sapphire), a polymer, or combinations thereof. In addition, an exterior coating and/or an interior coating may be disposed on the front cover **152**. Examples of exterior coatings include, but are not limited to, smudge-resistant (e.g., oleophobic) and anti-reflective coatings. Examples of interior coatings include, but are not limited to, masking layers. In some cases, the front cover **152** may be part of a cover assembly that includes a mounting frame which is coupled to an interior and/or side surface of the cover **152** and to the enclosure component **110**. The front cover **152** (in combination with any exterior surface coatings) may at least partially define a front surface **102** of the device.

The device **100** may also include a rear cover (e.g., rear cover **254** of FIG. **2**A). In some embodiments, the rear cover is positioned over a sensing panel (e.g., a rear-facing sensing panel) of the device **100**. As discussed in more detail with respect to FIG. **2**A, the sensing panel may include one or more optical modules and the rear cover may be configured to transmit light in one or more frequencies used by the optical modules. In additional embodiments, the rear cover may define one or more openings positioned over one or more of the optical modules and windows may be placed over the openings. The rear cover may be formed of a glass, a glass ceramic, a ceramic (such as sapphire), or combinations thereof. In addition, the rear cover may be formed of one or more layers of a glass, a glass ceramic, a ceramic (such as sapphire), a polymer, or combinations thereof. In addition, an exterior coating and/or an interior coating may be disposed on the rear cover. Examples of exterior coatings include, but are not limited to, smudge-resistant (e.g., oleophobic) and anti-reflective coatings. Examples of interior coatings include, but are not limited to, masking layers. The rear cover (in combination with any exterior surface coatings) may at least partially define a rear surface **104** of the device.

The display assembly **172** may be disposed within the internal cavity. The dashed lines in FIG. **1** indicate a periphery of the display assembly **172**. The display assembly **172** may be configured to produce graphical output which is transmitted through a substantially transparent portion of the front cover **152**. The display assembly **172** may include a display component such as a pixel definition layer, a touch sensitive layer, and the like. As examples, the display component may include one or more layers of a liquid-crystal display (LCD), a light-emitting diode (LED) display, an LED-backlit LCD display, an organic light-emitting diode (OLED) display, an active layer organic light-emitting diode (AMOLED) display, and the like. In some cases, the display assembly **172** includes a touch sensitive layer. A display component including both a display layer and a touch sensitive layer may be referred to as a touch sensitive display component (or simply as a touch sensitive display). The display assembly may also include a display control circuit. In some embodiments, the display assembly **172** may be attached to (or may abut) the front cover **152**.

In embodiments, the display assembly **172** also includes a first antenna element of a wireless communication system. In some cases, the first antenna element may be a resonating antenna element and may therefore also be referred to as a first resonating antenna element or as a display resonating antenna element. The first antenna element **278** is indicated in the detail view of FIG. **2**B and the description provided with respect to FIGS. **2**A and **2**B is generally applicable herein.

In embodiments, the first antenna element may comprise one or more conductive elements (alternately, structures) in the display assembly. In some cases, one or more of the conductive elements may be a dedicated or separate element of the display assembly. Alternatively, one or more of the conductive elements may not be a dedicated or separate element of the display and may be time-multiplexed or otherwise operated in a fashion that allows it to serve multiple functions, as an antenna and as an operational element of the display. In some examples, the antenna element is formed by a functional electrode layer or existing conductive layer of the display assembly. In some embodiments, the display assembly comprises a circuit assembly (e.g., **973** of FIG. **9**) and the circuit assembly comprises the first antenna element. The conductive elements may be provided on a dielectric substrate of the circuit assembly, such as a circuit board. The additional discussion of the circuit assembly **973** provided with respect to FIG. **9** is generally applicable herein and is not repeated here.

In some embodiments, the housing **110** defines a second antenna element of the wireless communication system. In some cases, the second antenna element may be a resonating antenna element and may therefore also be referred to herein as a second resonating antenna element or as a housing resonating antenna element. In additional embodiments, the conductive upper portion **112** of the housing defines the second antenna element. The first antenna element may be operatively coupled to the second antenna element. For example, the first antenna element may be conductively coupled to the second antenna element (e.g., the conductive upper portion **112** of the housing **110**). When the first antenna element is included in a circuit assembly, the circuit assembly may be conductively coupled to the second antenna element (e.g., the conductive upper portion **112** of the housing **110**). In embodiments, connections between the display assembly and the upper portion of the housing are made at a plurality of discrete locations, such as from 2 to 10 locations, from 3 to 10 locations, from 4 to 10 locations, or from 4 to 8 locations. The lower portion **114** of the housing **110** may define an antenna ground.

In embodiments, the wireless communication system includes a feed and a ground. In some embodiments, the feed is coupled to at least one of the first antenna element or the second antenna element. For example, the feed may include a positive feed terminal coupled to at least one of the first antenna element or the second antenna element (e.g., the conductive upper portion **112** of the housing **110**). In this example, the positive feed terminal may also be coupled to one or more of a transmitter (alternately, an emitter), a receiver, or a transceiver. In additional embodiments, an electrical ground (e.g., a system ground, also referred to as a ground reference potential or simply as a ground) is coupled to the antenna ground defined by the housing (e.g., the conductive lower portion **114**). In some cases, an antenna ground within the display assembly is also coupled to the ground, such as through a ground feed terminal of the feed. The more detailed description of location of the feed(s) and ground(s) of the wireless communication system provided with respect to FIGS. **4**A through **7**C is generally applicable herein and is not repeated here. The display assembly **172** may be coupled to the upper portion **112** of the housing **110** in a variety of ways and the description of coupling arrangements provided with respect to FIGS. **10**A through **15** is generally applicable herein.

As previously mentioned, both the first antenna element and the second antenna element may resonate during operation of the wireless communication system. The antenna element(s) of the wireless communication system may be configured to resonate at one or more desired frequencies or within one or more desired frequency ranges. In some cases, the wireless communication system may be a radio-frequency communication system. As examples, the antenna element(s) of the wireless communication system may be configured to resonate in a frequency range that includes a frequency of about 1.2 GHz, such as from about 0.6 GHz to about 10 GHz or from about 1 GHz to about 9 GHz. In additional examples, the antenna element(s) of the wireless communication system may be configured to resonate in one or more of frequency ranges or bands described herein.

Wireless communication protocols and standards may include established protocols and standards such as IEEE 802.11x, GSM, LTE, CDMA, TDMA, 3G, 4G, 5G, Bluetooth, Bluetooth Low Energy (BLE), ISO/IEC 18000-3, Wi-Fi, Radio-frequency identification (RFID), Near-Field

Communication (NFC), Global Positioning System (GPS) or any other target wireless communication protocol or standard (including yet-to-be-developed protocols and/or standards).

In some embodiments, the slot **130** (with the dielectric portion **134**) may be configured to operate as a radiating element of the wireless communication system. As shown in the example of FIG. **1**, the slot **130** is oriented so that a long direction of the slot **130** is aligned with a lateral dimension of the housing **110**. In addition, the slot **130** and the dielectric portion **134** extend across at least two of the four sides defined by the housing **110**. The example of FIG. **1** is not limiting and in additional embodiments a housing may include a plurality of openings and one or more of these openings may be configured to operate as a radiating element for an antenna, as shown in the examples of FIGS. **6**A to **7**C.

In some embodiments, the electronic device may be configured to maintain the performance of the electronic device when the device is submerged or subjected to wet environmental conditions. In some cases, ingress of a conducting fluid like water into a gap (alternately, void) between an interior surface of the housing and one or more internal components of the device can change the electrical properties of the system, which may result in a change in a performance of the antenna or other electronic components of the device. To help reduce the impact of moisture or liquid ingress, the electronic device may include an electrically insulating element configured to maintain the dielectric insulation between components or otherwise maintain the operation of the antenna(s) of the device. In some embodiments, the electrically insulating element(s) may be configured to help to electrically isolate an electrically conducting region or component of the housing by providing an insulating layer and/or by preventing ingress of the fluid into a portion of the gap or other opening. In some implementations described in more detail herein, the electrically insulating element may be positioned between the conductive lower portion of the housing and a connector component transmitting a signal to or from an antenna element of the wireless communication system. Alternately or additionally, the electrically insulating element may be positioned between the conductive upper and lower portions of the housing. FIGS. **16-20** show examples of a variety of electrically insulating elements, which include, but are not limited to, an electrically insulating gasket positioned within the gap and an electrically insulating material disposed over the electrically conducting region of the housing. The description provided with respect to FIGS. **16-20** is generally applicable herein and is not repeated here.

In additional implementations, the electrically insulating element may maintain the operation of one or more sensor systems of the electronic device by maintaining dielectric insulation between a conductive portion of the housing and an internal component of the sensor system that is operably coupled to the conductive portion. In some cases, the conductive portion of the housing may form an electrode or a terminal for the sensor system. For example, the conductive upper portion of the housing may form an electrode or a terminal for the sensor system. As previously discussed, the sensor system may be a health monitoring or biosensor system, such an electrocardiogram (ECG) sensor system, a heart rate sensor system, a galvanic skin response system, a bioimpedance sensor system, or the like. The sensor system may be configured to measure a physical state or condition of a user through physical contact between the user, the electrode, or the terminal, which may occur through the user wearing the electronic device or simply touching the electrode or terminal.

The device **100** may include one or more electronic components in addition to the display assembly **172**. For example, the device **100** may include at least one of a receiver, a transmitter, or a transceiver of the wireless communication system and may also include a wireless communication circuit. More generally, these additional components may comprise one or more of a processing unit, control circuitry, memory, an input/output device, a power source (e.g., battery), a charging assembly (e.g., a wireless charging assembly), a network communication interface, an accessory, and a sensor. Components of a sample electronic device are discussed in more detail below with respect to FIG. **22** and the description provided with respect to FIG. **22** is generally applicable herein.

In the example of FIG. **1**, the electronic device **100** includes a crown module which includes the input member **103**. The crown module may be positioned at least partially within an aperture formed in a side of the housing **110**. The input member **103** may have an outer surface configured to receive a rotary user input. In addition, the input member **103** may provide an electrode for a biosensor within the electronic device **100**. For example, the input member **103** may include an electrode which can be used for taking an electrocardiogram. The housing **110** can form one or more other electrodes for taking the electrocardiogram or a conductive terminal may be formed on the housing to serve as the other electrode. The input member may be offset with respect to a centerline of the housing **110** as described in more detail with respect to FIG. **3**.

The electronic device **100** may also comprise a sensing panel, as shown in FIG. **2**A. The sensing panel may include one or more sensor assemblies. For example, the one or more sensor assemblies may be one or more health monitoring sensor assemblies or biosensor assemblies, such an electrocardiogram (ECG) sensor, a photoplethysmogram (PPG) sensor, a heart rate sensor, a pulse oximeter or other oxygen sensor, or other bio-sensor. The additional description of sensors, sensor assemblies, and sensing panels provided with respect to FIGS. **2**A and **22** is generally applicable herein.

In some cases, an internal device component is configured to receive radio frequency (RF) signals. For example, the RF signals may be in a frequency range from about 0.6 GHz to about 10 GHz or from about 1 GHz to about 9 GHz. The frequency range may be a "low band" frequency range (e.g., less than 1 GHz, such as about 400 MHz to less than 1 GHz, about 600 MHz to about 900 MHz, or 600 MHz to 700 MHz), a "mid-band" frequency range (e.g., about 1 GHz to about 6 GHz, such as about 1 GHz to about 2.6 GHz, about 2 GHz to about 2.6 GHz, about 2.5 GHz to about 3.5 GHz, or about 3.5 GHz to about 6 GHz), or a "high-band" frequency range (e.g., about 24 GHz to about 40 GHz, about 57 GHz to about 64 GHz, or about 64 GHz to about 71 GHz). In addition, wireless charging ranges may broadly be from about 80 kHz to about 300 kHz or from about 110 kHz to about 205 kHz. In some cases, the housing may comprise a dielectric housing component configured to provide a "window" for an RF transmitter, an RF receiver, and/or an RF transceiver. For example, the RF transmitter, the RF receiver, and/or the RF transceiver may be part of a wireless communication system or a wireless charging system.

FIG. **2**A shows an example cross-sectional view of an electronic device. The device **200** may be an example of the electronic device **100** and the cross-section may be taken along A-A. FIG. **2**B is a detail view of the device **200** of FIG. **2**A in area **1**-**1**.

The electronic device **200** includes a housing **210**, a front cover **252**, and a rear cover **254**. The housing **210**, the front cover **252**, and the rear cover **254** may together be referred to as an enclosure **205**. The device **200** defines a front surface **202**, a rear surface **204**, and a side surface **206**. The housing **210** may also define an internal cavity **201** and a front opening **282** and a rear opening **284** to the internal cavity. The electronic device **200** also includes a display assembly **272** positioned within the internal cavity **201** and under the front cover **252**. The display assembly **272** includes a first antenna element **278** (see FIG. **2**B) and also includes a display component.

The first antenna element **278** may be a resonating antenna element. The location of the first antenna element **278** shown in FIG. **2**B is exemplary rather than limiting. In some examples, the antenna element is formed by a functional electrode layer or existing conductive layer of the display assembly, as previously discussed with respect to FIG. **1**. In embodiments, the first antenna element **278** may extend substantially across a lateral area of the display assembly or may be localized to a smaller area, such as near a corner or a side of the housing or centrally within the display assembly. The description provided with respect to the display assembly **172** and conductive coupling of antenna elements of the display assembly to other elements of the wireless communication system is applicable to the display assembly **272** and is not repeated here.

In the example of FIGS. **2**A and **2**B, the housing **210** includes a conductive upper portion **212** and a conductive lower portion **214**. The upper portion **212** at least partially surrounds a side surface **264** of the front cover **252**. The upper portion **212** of the housing **210** also defines a second antenna element of a wireless communication system, which may be a resonating antenna element.

The housing **210** defines a slot **230**. The slot **230** is positioned on at least a side surface **217** of the housing **210** and may therefore also be referred to as a side slot. The slot is positioned between the upper portion **212** and the lower portion **214**. A dielectric portion **234** of the housing **210** is positioned within the slot **230** and may substantially fill the slot **230**. This dielectric portion **234** may also be referred to herein as a dielectric member. In some cases, the dielectric portion **234** may extend beyond the slot **230** and into the interior cavity **201**, as shown in the examples of FIGS. **10**A and **10**B. An example of a slot which has not yet been filled with a dielectric material (other than air) is shown in FIG. **3**. The description provided with respect to the housing **110**, the upper portion **112**, the lower portion **114**, the slot **130**, the dielectric portion **134**, and connective coupling of feed(s) and ground(s) to portions of the housing **110** is applicable to the housing **210**, the upper portion **212**, the lower portion **214**, the slot **230**, the dielectric portion **234**, and connective coupling of feed(s) and ground(s) to portions of the housing **210** and is not repeated here.

In some embodiments, the slot **230** is configured to operate as a radiating element of the wireless communication system. In some cases, the slot **230** (with the dielectric **234**) is configured to radiate electromagnetic radiation at a particular frequency and/or in a particular frequency range. For example, the desired frequency range may be from about 1 GHz to about 9 GHz. The length of the slot may be configured so that the slot radiates at one or more desired frequencies. For example, the length of the slot may be one half of a desired wavelength of electromagnetic radiation (e.g., about 150 mm to about 17 mm). The slot **230** may be oriented so that a long direction of the slot **230** is aligned with a lateral dimension of the housing **210**, as was previously shown in FIG. **1** and is also shown in FIGS. **3** through **7**C. The slot **230** may extend across multiple sides of the housing as shown in the examples of FIGS. **1** and **3** through **7**C.

In additional embodiments, the slot **230** may be configured to define a minimum gap height and/or a minimum overlap between the edges **223** and **225**. As shown in the detail view of FIG. **2**B, the slot **230** is defined by a surface **223** of the upper portion **212** and by a surface **225** of the lower portion **214**. The surfaces **223** and **225** may also be referred to herein as edge surfaces or simply as edges. The edge surface **223** is separated from the edge surface **225** by a distance referred to herein as a gap height H_2. As shown in FIG. **2**B the gap height H_2 is substantially uniform but this example is not limiting and in additional examples the gap height H_2 between the surfaces **223** and **225** may vary, as shown in FIGS. **10**A, **10**B and **13** to **15**. The slot may therefore be configured to have a minimum gap height. By the way of example, the gap height, which may in some cases be a minimum gap height, may be from about 1 mm to about 2 mm, from about 1.25 mm to about 2 mm, or from about 1 mm to about 1.75 mm. In some cases, these gap height values may refer to averaged minimum gap height values.

The edge surface **223** may face at least a portion of the edge surface **225** and defines an overlap with the edge surface **225**. The upper portion **212** and the lower portion **214** may be configured to define a minimum overlap O_2. By the way of example, the minimum overlap may be from 1.0 mm to 2.5 mm or from 1.25 mm to 2.25 mm.

The upper portion **212** may define a front (or upper) surface **221**, a side surface **222**, an edge surface **223**, and an interior surface **224**, as shown in the detail view of FIG. **2**B. The edge surface **223** may correspond to the lower surface of the upper portion **212**. FIG. **2**B also shows the side surface **226**, the edge surface **225**, and the interior surface **227** of the lower portion **214**. The edge surface **225** may correspond to the upper surface of the lower portion **214**. In the example of FIGS. **2**A and **2**B, the upper portion **212** defines an internal ledge **216** that supports the front cover **252**. In some cases, the upper portion **212** or the lower portion **214** may define an internal ledge which can support the front cover **252**, the display assembly **272**, or both as shown in the examples of FIGS. **10**A through **15**.

In some embodiments, the upper portion **212** and the lower portion **214** may differ in height and/or thickness. In the example of FIGS. **2**A and **2**B, the upper portion **212** has a height less than a height of the lower portion **214** (e.g., as measured from the upper surface **221** to the edge surface **223**). In the example of FIGS. **2**A and **2**B, the upper portion **212** is generally thinner than the lower portion **214**, except at the ledge **216** (e.g., as measured from the side surface **222** to the interior surface **224**).

The dielectric portion **234** may substantially fill the slot **230** and in some cases may extend beyond the slot, as previously discussed. In other words, in some cases the dielectric portion is thicker than the upper portion **212**, the lower portion **214**, or both. When the dielectric portion **234** is thicker than an adjacent portion of the housing it can provide support to the adjacent portion of the housing. The dielectric portion may define an upper surface **241**, a side surface **242** (also referred to as an exterior surface), a lower surface **243**, and an interior surface **244**. The upper surface **241** may define an interface with the edge surface **223** and the lower surface **243** may define an interface with the edge surface **225**. The upper surfaces **241** and **243** of the dielectric portion **234** may be bonded to the edge surfaces **223** and **225**, respectively.

In embodiments, each of the conductive upper portion **212** and the conductive lower portion **214** includes or is formed of a conductive material. In some cases, the (electrically) conductive material comprises one or more metals and, in some cases, may be an iron-based alloy (such as steel), a titanium-based alloy, an aluminum-based alloy, a magnesium-based alloy, or the like. In some examples, the conductive upper portion **212** and the conductive lower portion **214** may form a unitary conductive housing member (also, component) in combination with a conductive bridge portion of the housing, as shown in FIG. **3**. In these examples, the upper portion **212**, the lower portion **214**, and the bridge portion may be formed from a single piece of material.

The dielectric portion **234** may be formed of one or more solid dielectric materials such as a polymer, a ceramic, or a composite of these. Suitable thermoplastic polymers include, but are not limited to, polyester-based polymers such as a polyethylene terephthalate-based polymer or a polybutylene terephthalate-based polymer. Suitable thermoset polymers include, but are not limited to, epoxy-based polymers or polyurethane-based polymers. In some cases, the dielectric material of the dielectric portion may have a dielectric constant (also referred to as the relative permittivity) ranging from 1.5 to 4, from 2 to 4, or 2.5 to 3.5 at a desired frequency range or over a desired frequency range. The description of suitable dielectric materials provided herein is not limited to the example of FIGS. **2**A and **2**B but is generally applicable herein.

The housing **210** may be configured to help prevent separation of the upper portion **212**, the lower portion **214**, and the dielectric portion **234** in the event of impact to the housing. For example, the material(s) used to form the dielectric portion may have mechanical properties which provide impact resistance to the housing. In some cases, bonding between the dielectric portion **234** and the upper portion **212** and the lower portion **214** may be enhanced by surface modification of the edge surfaces **223** and **225** and/or formation of retention features (also referred to as interlock features) on the upper portion **212** and/or the lower portion **214**. For example, a retention feature may have the form of a recess, a protrusion, and/or an angled portion on a surface of the upper portion **212**, the lower portion **214**, or both. In some cases, a retention feature may be formed on the edge **223**, the edge **225**, or both. Alternatively or additionally, a retention feature may be formed along an interior surface of the upper portion **212** and/or the lower portion **214** and the dielectric portion may extend along this interior surface and into and/or around the retention feature. Alternatively or additionally, extension of the dielectric portion beyond the slot **230** and along an interior surface of one or more of the upper portion **212** or the lower portion **214** may help provide structural integrity to the housing **210** even when the interior surface does not define a retention feature. The additional description of retention features provided with respect to FIGS. **10**A, **10**B, and **13** to **15** is generally applicable herein and not repeated here.

In some cases, a gap is present between an interior surface of the housing **210** and one or more internal components of the device. In the example of FIG. **2**B, the interior surface **224** of the upper portion **212** of the housing **210** and the side surface **264** of the front cover **252** partly define a gap **283** (also referred to as a void **283**). In this example, the ledge **216** defines a bottom of the gap **283**. In additional examples, the gap may extend deeper into the housing and may be defined by additional portions of the housing and/or additional internal components of the electronic device. As examples, an interior surface of the dielectric portion and/or a frame around the display assembly may at least partially define the gap, as shown in the examples of FIGS. **16**-**20**.

In the example of FIG. **2**B, the electronic device **200** may not require that an interposing electrically insulating element be provided within the gap **283** in order to prevent liquid or moisture from interfering with the operation of the antenna. However, the front cover **252** is typically coupled to the internal ledge **216** in order to restrict any liquid that may enter the gap **283** from moving deeper into the device.

As previously discussed, in additional examples the electronic device may include an electrically insulating element that is configured to reduce an impact on electrical performance due to a conductive fluid entering the gap. In embodiments, the electrically insulating element(s) may be configured to shield, insulate, encapsulate, or otherwise cover at least a portion of an interior surface of the housing. FIGS. **16**-**20** show examples of electronic devices including such an electrically insulating element, which may also be referred to herein as an interposing element or a sealing element. In some cases, the electrically insulating element is formed of a dielectric material, such as a polymer material and/or a polymer composite material. The following description of such electrically insulating elements, including the description provided with respect to FIGS. **16**-**20**, is generally applicable herein.

In the example of FIGS. **2**A and **2**B, the front surface **221** of the housing **210** is substantially flush with a front surface **262** of the cover **252**. In additional examples, the front surface **221** may be proud of the front surface **262** of the cover, as shown in FIGS. **10**A through **15**. In some examples, the front surface **221** defines a plane or a planar region and the plane or planar region is substantially parallel to a plane defined by the front surface **262** of the cover **252**. In some examples, the dielectric portion may be positioned closer to the front surface **221** than to the rear surface of the housing.

In the example of FIGS. **2**A and **2**B, the side surface **222** of the upper portion **212**, the side surface **242** of the dielectric portion, and the side surface **226** of the lower portion **114** define a substantially smooth and continuous region of the side surface **206**. For example, the side surfaces **222**, **226**, and **242** may be co-machined to produce the substantially smooth and continuous region of the side surface **206**. In some embodiments, the side surfaces **222**, **226**, and **242** need not be completely flush with one another, as shown in FIG. **2**B. In the example of FIG. **2**B, the side surface **226** and part of the side surface **242** is proud of the side surface **222**.

In some embodiments, the side surface **222** of the upper portion **212** defines a contour which differs from a contour defined by the side surface **226** of the lower portion **214**. For example, the side surface **222** may define a contour that includes a first region that is substantially perpendicular to a planar region of the front surface **221** of the housing **210** (and/or a plane defined by the front surface **262** of the cover **252**). For example, this first region may define a first angle ranging from about 85 degrees to 100 degrees with respect to a planar region of the front surface **221** of the housing **210** (and/or a plane defined by the front surface **262** of the cover **252**). The contour of the side surface **222** may also include a second region that defines a second angle that is greater than the first angle and that is obtuse with respect to a planar region of the front surface **221** of the housing **210** (and/or a plane defined by the front surface **262** of the cover **252**). The second region may be positioned closer to the slot **230** than the first region. The side surface **226** of the lower portion **214** may define a variety of contour shapes. For example, a contour of the side surface **226** may include a region near the slot **230** that defines an obtuse angle with respect to a plane defined by the front surface **262** of the cover **252**. This obtuse angle may be greater than the obtuse angle defined by the side surface **222** near the slot. The side surface **242** of the dielectric portion **234** may define a contour which provides a transition between the contours defined by the side surfaces **222** and **226**. In some cases, the contour defined by the side surface **242** may be concave (e.g., as shown in FIG. **10**A).

In embodiments, the front cover **252** is substantially transparent or includes one or more substantially transparent portions over the display assembly **272**. The front cover **252** defines a front surface **262** and a side surface **264** (see FIG. **2**B). In the example of FIGS. **2**A and **2**B, the front surface **262** is generally planar. However, this example is not limiting and in additional examples the front surface may define a curved contour. In the example of FIGS. **2**A and **2**B, the side surface **264** is generally planar. However, this example is not limiting and in additional examples the side surface may include one or more rounds and/or chamfers as shown in the examples of FIGS. **10**A to **15**. The front surface **262** of the front cover **252** (in combination with any exterior surface coatings) partially defines a front surface **102** of the device. The front cover **252** may be similar to the front cover **152** in terms of materials, dimensions, and other properties and, for brevity, that description is not repeated here.

As shown in FIG. **2**A, the rear cover **254** is positioned over a sensing panel **279** (e.g., a rear-facing sensing panel) of the device **200**. The sensing panel may include one or more optical modules as discussed in more detail below. Therefore, the rear cover may be configured to transmit light in one or more frequencies used by the optical modules. In additional examples, the rear cover **254** may define one or more openings positioned over one or more of the optical modules and windows may be placed over the openings. The rear cover **254** may be similar to the rear cover described with respect to device **100** in terms of materials and dimensions and, for brevity, that description is not repeated here.

The rear cover **254** defines a rear surface **264**. As shown in FIG. **2**A, the rear surface **264** defines a convex outer contour. In additional examples, the rear surface **264** may be substantially planar (also referred to as flat). The rear surface **264** (in combination with any exterior surface coatings) partially defines a rear surface **204** of the device, as shown in FIG. **2**A.

The electronic device **200** comprises a sensing panel **279**. The sensing panel **279** may include one or more sensor assemblies. For example, the one or more sensor assemblies may be one or more health monitoring sensor assemblies or biosensor assemblies, such as an electrocardiogram (ECG) sensor, a photoplethysmogram (PPG) sensor, a heart rate sensor, a pulse oximeter or other oxygen sensor, or other bio-sensor. In some cases, a sensor assembly is configured to illuminate the tissue of the user wearing the device and then measure light that is transmitted back to the device.

In some embodiments, the sensing panel **279** includes a biosensor assembly which includes one or more emitter modules and one or more receiver modules. For example, a heart rate biosensor may include an emitter module which produces a visible light signal (e.g., green light) and which produces an infrared light signal. As another example, a pulse oximetry biosensor (e.g., an SpO_2 sensor) may include an emitter module which produces an optical signal over a wavelength range at which the absorption of oxygenated hemoglobin and deoxygenated hemoglobin is different (e.g., red light) and which produces an optical signal over a wavelength range at which the absorption of oxygenated hemoglobin and deoxygenated hemoglobin is similar (e.g., green light or infrared light). The biosensor assembly may include a chassis positioned below the rear cover **254** and the emitter module(s) and receiver module(s) may be attached to the chassis.

The electronic device **200** may further include a crown module which may include an input member as previously described with respect to FIG. **1**. The input member may be offset with respect to a centerline of the housing **210** between the front surface **221** and the rear surface. The additional description of the crown module and the input member provided with respect to FIG. **1** is generally applicable herein and is not repeated here.

The internal components **274** and **276**, shown schematically in FIG. **2**A, may be one or more of a wireless communication component such as a transmitter, a receiver, or a transceiver. Alternately or additionally, the internal components **274** and **276** may be one or more of a processing unit, control circuitry, memory, an input/output device, a power source (e.g., battery), a charging assembly (e.g., a wireless charging assembly), a network communication interface, an accessory, and a sensor. Components of a sample electronic device are discussed in more detail below with respect to FIG. **22** and the description provided with respect to FIG. **22** is generally applicable herein.

FIG. **3** shows a view of an example housing member for an electronic device. The housing member **311** is a unitary structure that defines four sides (**306***a*, **306***b*, **306***c*, and **306***d*) and four transitions between the sides (**308***a*, **308***b*, **308***c*, and **308***d*). These transitions may also be referred to as corners herein. The housing member **311** may be a simplified example of a housing member included in the electronic device **100**, **200**, or any other electronic device described herein. The housing member **311** may also be referred to herein as a housing component.

The housing member **311** defines a slot **330** (which may also be referred to herein as an opening). The slot **330** is positioned on at least one side of the housing member **311** and may therefore also be referred to as a side slot. As previously described with respect to FIGS. **2**A and **2**B, the housing member **311** may be a conductive housing member and the slot **330** may be configured to radiate electromagnetic radiation at a particular frequency and/or in a particular frequency range. The length of the slot, L_3, may be configured so that the slot radiates at one or more desired frequencies. For example, the length of the slot may be one half of a desired wavelength of electromagnetic radiation. The example of FIG. **3** is not limiting and in additional embodiments a housing may include a plurality of slots, one or more of which may be configured to operate as a radiating element for an antenna, as shown in the examples of FIGS. **5**A to **7**C.

In the example of FIG. **3**, the slot **330** extends across three of the sides and onto the fourth side so that all four of the sides and all four of the corners define the slot. The slot **330** may also be configured to define a minimum gap height and/or a minimum overlap between the edges defining the slot, as previously described with respect to FIGS. **2**A and **2**B. The additional description provided with respect to FIGS. **2**A and **2**B with respect to slot dimensions and frequency ranges is generally applicable herein and is not repeated here. The example of FIG. **3** is not limiting and in additional embodiments a slot may extend across a fewer number of sides and/or may vary in shape, as shown in the examples of FIGS. **5**A to **7**C.

The housing member **311** comprises an upper portion **312**, a lower portion **314**, and a bridge portion **318** and these three portions of the housing member define the slot **330**. In some cases, the conductive housing member **311** may be formed from a single piece of material. In the example of FIG. **3**, the bridge portion is located on only one side **306***a* of the housing member **311**, but in additional embodiments the housing member may define multiple bridge portions, such as in the examples of FIGS. **5**B and **6**B.

The housing member **311** also defines additional openings. For example, the housing member **311** defines a front opening **382** and a rear opening **384**. In addition, the housing member defines a side opening **387** and a side opening **388**, each of which may accommodate input members. For example, the side opening **387** may accommodate an input member for a crown module and the side opening **388** may accommodate a button input member. The example of FIG. **3** is not limiting, and the housing member may define additional side openings or other openings as desirable.

FIG. **4**A shows a top view of an example electronic device. The electronic device **400***a* may be an example of the device **100** of FIG. **1**. The electronic device **400***a* includes a housing **410***a* and a front cover **452***a* coupled to the housing. The electronic device also includes a wireless communication system. A feed **492***a* and a ground **494***a* of the wireless communication system are schematically illustrated in FIG. **4**A and additional elements of the wireless communication system are discussed in more detail below. The electronic device **400***a* also includes an input device **403***a* and an input device **405***a*. The front cover **452***a* may be similar to the front cover **152**, the input device **403***a* may be similar to the input device **103** and the input device **405***a* may be any of the input devices described with respect to FIGS. **1** and **22**.

The electronic device **400***a* also includes a display assembly positioned under the front cover **452***a* (as previously shown in FIG. **1**). The display assembly in turn includes a first antenna element, that may be a resonating antenna element, of a wireless communication system. The display assembly and the first antenna element may be as shown and described with respect to the display assembly **172** and the first antenna element **278** and that description is not repeated here.

The housing **410***a* also includes a conductive upper portion **412***a* and a conductive lower portion **414***a*. The housing **410***a* also defines a slot **430***a*, and a dielectric portion **434***a* of the housing **410***a* is positioned within the slot **430***a*. In embodiments, the conductive upper portion **412***a* defines a second antenna element, that may be a resonating antenna element, of the wireless communication system. The first antenna element may be operatively coupled to the second antenna element. For example, the first antenna element may be conductively coupled to the second antenna element (e.g., the conductive upper portion **412***a*). In embodiments, connections between the display assembly and the upper portion of the housing are made at a plurality of discrete locations, such as from 2 to 10 locations, from 3 to 10 locations, from 4 to 10 locations, or from 4 to 8 locations. In further embodiments, the slot **430***a* is configured to operate as a radiating element of the wireless communication system. The additional description provided with respect to the housings **110** and **210** is applicable to the housing **410***a* and is not repeated here.

As shown in FIG. **4**A, the housing **410***a* includes four sides **406***a*, **407***a*, **408***a*, and **409***a*. The first side of the housing **410***a* also includes a conductive bridge portion **418***a*. As previously discussed with respect to FIGS. **1**-**3**, the upper portion **412***a*, the lower portion **414***a*, and the bridge portion **418***a* of the housing **410***a* may be formed of a single piece of conductive material. In the view of FIG. **4**A, the dielectric portion **434***a* (and the slot **430***a*) is located on a first region of a first side **406***a*, on each of the sides **407***a*, **408***a*, and **409***a*, and on a second region of the first side **406***a*. In particular, the dielectric portion **434***a* extends across each of the sides **407***a*, **408***a*, and **409***a*. The shape of the dielectric portion **434***a* may be described as a "C-shape." An approximate length L_4 of the slot is also shown in FIG. **4**A. The side **408***a* may be generally opposite the side **406***a* and the side **409***a* may be generally opposite the side **407***a*.

As shown in FIG. **4**A, the feed **492***a* is positioned away from the side **406***a* and near a corner between the sides **408***a* and **409***a*. The feed **492***a* may transmit a positive antenna signal to and/or may receive a positive antenna signal from the wireless communication system. As previously described with respect to FIG. **1**, in some embodiments the feed **492***a* is coupled to at least one of the first antenna element and the second antenna element. In some cases, the feed may include a positive feed terminal that is conductively coupled to at least one of the first antenna element or the second antenna element (e.g., the conductive upper portion **412***a*). For example, the positive feed terminal may be coupled to the first antenna element (within the display assembly). The additional description of conductive coupling between these two antenna elements provided with respect to FIGS. **1** and **9** to **15** is generally applicable herein and is not repeated here.

The ground **494***a* is positioned along the side **406***a*. The ground **494***a* is conductively coupled to the side **406***a* of the housing **410***a* and in some embodiments is conductively coupled to the lower portion **414***a*. In the example of FIG. **4**A, the ground **494***a* is conductively coupled to the side **406***a* over a region that has a lateral dimension similar to that of the bridge portion **418***a* (as indicated by the dashed line).

During operation of the wireless communication system, the lower portion **414***a* may be held at a ground potential (which may be a ground reference potential). The regions of the upper portion **412***a* which are generally positioned above the slot **430***a* are fed to have a potential which generally differs from that of the ground potential. In some cases, the conductive coupling between the upper portion **412***a* and the antenna element of the display assembly may provide a common potential to both antenna elements.

FIG. **4**B shows a top view of another example electronic device. The electronic device **400***b* may be another example of the electronic device **100** of FIG. **1**. The electronic device **400***b* includes a housing **410***b* and a front cover **452***b* coupled to the housing. The electronic device also includes a wireless communication system. A feed **492***b*, a ground **494***b*, and an optional switchable ground **495***b* of the wireless communication system are schematically illustrated in FIG. **4**B and additional elements of the wireless communication system are discussed in more detail below. The electronic device **400***b* also includes an input device **403***b* and an input device **405***b*. The front cover **452***b* may be similar to the front cover **152**, the input device **403***b* may be similar to the input device **103** and the input device **405***b* may be any of the input devices described with respect to FIGS. **1** and **22**.

The electronic device **400***b* also includes a display assembly positioned under the front cover **452***b* (as previously shown in FIG. **1**). The display assembly in turn includes a first antenna element, that may be a resonating antenna element, of a wireless communication system. The display assembly and the first antenna element may be as shown and described with respect to the display assembly **172** and the first antenna element **278** and that description is not repeated here.

The housing **410***b* also includes a conductive upper portion **412***b* and a conductive lower portion **414***b*. The housing **410***b* also defines a slot **430***b*, and a dielectric portion **434***b* of the housing **410***b* is positioned within the slot **430***b*. In embodiments, the conductive upper portion **412***b* defines a second antenna element, that may be a resonating antenna element, of the wireless communication system. The first antenna element may be operatively coupled to the second antenna element. For example, the first antenna element may be conductively coupled to the second antenna element (e.g., the conductive upper portion **412***b*). In embodiments, connections between the display assembly and the upper portion of the housing are made at a plurality of discrete locations, such as from 2 to 10 locations, from 3 to 10 locations, from 4 to 10 locations, or from 4 to 8 locations. In further embodiments, the slot **430***b* is configured to operate as a radiating element of the wireless communication system. The additional description provided with respect to the housings **110**, **210***a*, and **210***b* is applicable to the housing **410***b* and is not repeated here.

As shown in FIG. **4**B, the housing **410***b* includes four sides **406***b*, **407***b*, **408***b*, and **409***b*. The first side of the housing **410***b* also includes a conductive bridge portion **418***b*. As previously discussed with respect to FIGS. **1-3**, the upper portion **412***b*, the lower portion **414***b*, and the bridge portion **418***b* of the housing **410***a* may be formed of a single piece of conductive material. In the view of FIG. **4**B, the dielectric portion **434***b* (and the slot **430***b*) is located on a first region of a first side **406***b*, on each of the sides **407***b*, **408***b*, and **409***b*, and on a second region of the first side **406***b*. In particular, the dielectric portion **434***b* extends across each of the sides **407***b*, **408***b*, and **409***b*. The side **408***b* may be generally opposite the side **406***b* and the side **409***b* may be generally opposite the side **407***b*.

As shown in FIG. **4**B, the feed **492***b* is positioned away from the side **406***b* and near a transition (e.g., a corner) between the sides **408***b* and **409***b*. The feed **492***b* may transmit a positive antenna signal to and/or may receive a positive antenna signal from the wireless communication system. As previously described with respect to FIGS. **1** and **4**A, in some embodiments the feed **492***b* is coupled to at least one of the first antenna element and the second antenna element. The additional description of conductive coupling between these two antenna elements provided with respect to FIGS. **1** and **9** to **15** is generally applicable herein and is not repeated here.

The ground **494***b* is positioned along the side **406***b* of the housing **410***b*. The ground **494***b* is conductively coupled to the side **406***b* and in some embodiments is conductively coupled to the lower portion **414***b* of the housing **410***b*. The switchable ground **495***b* (alternately, switched ground) is positioned along the side **408***b* and in some cases may hold a region of the side **408***a* at a ground potential when the switchable ground **495***b* is activated. In some cases, the switchable ground **495***b* may be conductively coupled to the upper portion **412***b* when activated. The switchable ground **495***b* may be used to modify the resonance of the first and the second antenna elements, such as by shifting one or more resonance peaks.

FIG. **5**A shows a view of another example electronic device. The electronic device **500***a* includes a housing **510***a* and a front cover **552***a* coupled to the housing. The electronic device also includes a wireless communication system and additional elements of the wireless communication system are discussed in more detail below. The electronic device **500***a* also includes an input device **503***a* and a band **560***a*. The front cover **552***a* may be similar to the front cover **152**, the input device **503***a* may be similar to the input device **103**, and the band **560***a* may be similar to the band **160**.

The electronic device **500***a* also includes a display assembly positioned under the front cover **552***a* (as previously shown in FIG. **1**). The display assembly in turn includes a first antenna element, that may be a resonating antenna element, of a wireless communication system. The display assembly and the first antenna element may be as shown and described with respect to the display assembly **172** and the first antenna element **278** and that description is not repeated here.

The housing **510***a* includes a conductive upper portion **512***a* and a conductive lower portion **514***a*. The housing **510***a* also includes two conductive bridge portions as described below. The housing **510***a* also defines a slot **530***a*, and a dielectric portion **534***a* of the housing **510***a* is positioned within the slot **530***a*. The housing **510***a* also defines a slot **531***a*, and a dielectric portion **535***a* of the housing **510***a* is positioned within the slot **531***a*. In embodiments, the conductive upper portion **512***a* defines a second antenna element, that may be a resonating antenna element, of the wireless communication system. The first antenna element may be operatively coupled to the second antenna element. For example, the first antenna element may be conductively coupled to the second antenna element (e.g., the conductive upper portion **512***a*). In embodiments, connections between the display assembly and the upper portion of the housing are made at a plurality of discrete locations, such as from 2 to 10 locations, from 3 to 10 locations, from 4 to 10 locations, or from 4 to 8 locations. In further embodiments, the slots **530***a* and **531***a* are configured to operate as a radiating element of the wireless communication system. The additional description provided with respect to the housings **110**, **210***a*, and **210***b* is applicable to the housing **510***a* and is not repeated here. FIG. **5**B gives an example of how one or more feeds and one or more grounds may be incorporated into the electronic device **500***a*.

As shown in FIG. **5**A, the housing **510***a* includes four sides **506***a*, **507***a*, **508***a*, and **509***a*. The view of FIG. **5**A shows a conductive bridge portion on the side **508***a*; another conductive bridge portion is present on the side **506***a* as shown in the top view of FIG. **5**B (**519***b* and **518***b*, respectively). As previously discussed with respect to FIGS. **1-3**, the upper portion **512***a*, the lower portion **514***a*, and the bridge portions of the housing **510***a* may be formed of a single piece of conductive material. In the view of FIG. **5**A, the dielectric portion **534***a* (and the slot **530***a*) is located on a first region of the side **506***a*, on the side **507***a*, and on a first region of the side **508***a*. The dielectric portion **535***a* (and the slot **531***a*) is located on a second region of the side **506***a*, on the side **509***a*, and on a second region of the side **508***a*. In addition, although the dielectric portions **534***a* and **535***a* generally have a long dimension that aligns with a lateral dimension of the housing, each of the dielectric portions **534***a* and **535***a* defines a "step" (alternately, "jog") (**536***a*, **537***a*) that aligns with a vertical dimension of the housing **510***a*. The side **508***a* may be generally opposite the side **506***a* and the side **509***a* may be generally opposite the side **507***a*.

FIG. **5**B shows a top view of an example electronic device, which may be an example of the device of FIG. **5**A. The electronic device **500***b* includes a housing **510***b* and a front cover **552***b* coupled to the housing. The electronic device also includes a wireless communication system. A feed **592***b*, a ground **594***b*, and an optional switchable ground **595***b* of the wireless communication system are schematically illustrated in FIG. **5**B and additional elements of the wireless communication system are discussed in more detail below. The electronic device **500***b* also includes an input device **503***b* and an input device **505***b*. The front cover **552***b* may be similar to the front cover **152**, the input device **503***b* may be similar to the input device **103** and the input device **505***b* may be any of the input devices described with respect to FIGS. **1** and **22**.

The electronic device **500***b* also includes a display assembly positioned under the front cover **552***b* (as previously shown in FIG. **1**). The display assembly in turn includes a first antenna element, that may be a resonating antenna element, of a wireless communication system. The display assembly and the first antenna element may be as shown and described with respect to the display assembly **172** and the first antenna element **278** and that description is not repeated here.

The housing **510***b* includes a conductive upper portion **512***b* and a conductive lower portion **514***b*, and conductive bridge portions **518***b* and **519***b*. The housing **510***b* also defines a slot **530***b*, and a dielectric portion **534***b* of the housing **510***b* is positioned within the slot **530***b*. The housing **510***b* also defines a slot **531***b*, and a dielectric portion **535***b* of the housing **510***b* is positioned within the slot **531***b*. In embodiments, the conductive upper portion **512***b* defines a second antenna element, that may be a resonating antenna element, of the wireless communication system. The first antenna element may be operatively coupled to the second antenna element. For example, the first antenna element may be conductively coupled to the second antenna element (e.g., the conductive upper portion **512***b*). In embodiments, connections between the display assembly and the upper portion of the housing are made at a plurality of discrete locations, such as from 2 to 10 locations, from 3 to 10 locations, from 4 to 10 locations, or from 4 to 8 locations. In further embodiments, the slots **530***b* and **531***b* are configured to operate as a radiating element of the wireless communication system. The additional description provided with respect to the housings **110**, **210***a*, and **210***b* is applicable to the housing **510***a* and is not repeated here.

As shown in FIG. **5**B, the housing **510***b* includes four sides **506***b*, **507***b*, **508***b*, and **509***b*. In the view of FIG. **5**A, the dielectric portion **534***b* (and the slot **530***b*) is located on a first region of the side **506***b*, on the side **507***b*, and on a first region of the side **508***b*. The dielectric portion **535***b* (and the slot **531***b*) is located on a second region of the side **506***b*, on the side **509***b*, and on a second region of the side **508***b*. Each of the dielectric portions **534***b* and **535***b* also defines a "step" (**536***b*, **537***b*) similar to that previously described with respect to FIG. **5**A and that description is not repeated here. The bridge portions **518***b* and **519***b* are respectively positioned on the sides **506***b* and **508***b*. The side **508***a* may be generally opposite the side **506***a* and the side **509***a* may be generally opposite the side **507***a*.

The feed **592***b* is positioned away from the side **506***b* and near a transition (e.g., a corner) between the sides **508***b* and **509***b*. The feed **592***b* may transmit a positive antenna signal to and/or may receive a positive antenna signal from the wireless communication system. As previously described with respect to FIGS. **1** and **4**A, in some embodiments the feed **592***b* is coupled to at least one of the first antenna element and the second antenna element. The additional description of conductive coupling between these two antenna elements provided with respect to FIGS. **1**, **4**A, and **9** to **15** is generally applicable herein and is not repeated here.

As schematically shown in FIG. **5**B, the ground **594***b* is positioned along the side **506***b* (between the dielectric portions **534***b* and **535***b*). The ground **594***b* is conductively coupled to the side **506***b* of the housing **510***b* and in some embodiments is conductively coupled to the lower portion **514***b*. The switchable ground **595***b* is positioned along the side **508***b* and generally proximate the bridge **519***b*. In some cases, the switchable ground is optional and if present may be operated as previously described with respect to FIG. **4**B.

FIG. **6**A shows a view of another example electronic device. The electronic device **600***a* includes a housing **610***a* and a front cover **652***a* coupled to the housing. The electronic device also includes a wireless communication system and additional elements of the wireless communication system are discussed in more detail below. The electronic device **600***a* also includes an input device **603***a* and a band **660**. The front cover **652***a* may be similar to the front cover **152**, the input device **603***a* may be similar to the input device **103**, and the band **660***a* may be similar to the band **160**.

The electronic device **600***a* also includes a display assembly positioned under the front cover **652***a* (as previously shown in FIG. **1**). The display assembly in turn includes an antenna element, that may be a resonating antenna element, of a wireless communication system. The display assembly and its antenna element may be as shown and described with respect to the display assembly **172** and the first antenna element **278** and that description is not repeated here.

The housing **610***a* includes a conductive upper portion **612***a* and a conductive lower portion **614***a*. The housing **610***a* also includes two conductive bridge portions as described below. The housing **610***a* also defines a slot **630***a*, and a dielectric portion **634***a* of the housing **610***a* is positioned within the slot **630***a*. The housing **610***a* also defines a slot **631***a*, and a dielectric portion **635***a* of the housing **610***a* is positioned within the slot **631***a*. In embodiments, the conductive upper portion **612***a* defines one or more antenna elements, that may be one or more resonating antenna elements, of the wireless communication system. The antenna element of the display assembly may be operatively coupled to the antenna element(s) of the housing **610***a*. For example, the display antenna element may be conductively coupled to the housing antenna element(s). In further embodiments, each of the slots **630***a* and **631***a* are configured to operate as a radiating element of the wireless communication system. The additional description provided with respect to the housings **110**, **210***a*, and **210***b* is applicable to the housing **610***a* and is not repeated here. FIG. **6**B gives an example of how one or more feeds and one or more grounds may be incorporated into the electronic device **600***a*.

As shown in FIG. **6**A, the housing **610***a* includes four sides **606***a*, **607***a*, **608***a*, and **609***a*. The view of FIG. **6**A shows a conductive bridge portion **619***a* on the side **608***a*; another conductive bridge portion is present on the side **606***a* as shown in the top view of FIG. **6**B. As previously discussed with respect to FIGS. **1-3**, the upper portion **612***a*, the lower portion **614***a*, and the bridge portions (e.g., **619***a*) of the housing **610***a* may be formed of a single piece of conductive material. In the view of FIG. **6**A, the dielectric portion **634***a* (and the slot **630***a*) is located on a first region of the side **606***a*, on the side **607***a*, and on a first region of the side **608***a*. The dielectric portion **635***a* (and the slot **631***a*) is located on a second region of the side **606***a*, on the side **609***a*, and on a second region of the side **608***a*. The side **608***a* may be generally opposite the side **606***a* and the side **609***a* may be generally opposite the side **607***a*.

FIG. **6**B shows a top view of an example electronic device, which may be an example of the device of FIG. **6**A. The electronic device **600***b* includes a housing **610***b* and a front cover **652***b* coupled to the housing. The electronic device also includes a wireless communication system. Feeds **692***b* and **693***b* and grounds **694***b*, **695***b*, and **696***b* of the wireless communication system are schematically illustrated in FIG. **6**B and additional elements of the wireless communication system are discussed in more detail below. The electronic device **600***b* also includes an input device **603***b* and an input device **605***b*. The front cover **652***b* may be similar to the front cover **152**, the input device **603***b* may be similar to the input device **103** and the input device **605***b* may be any of the input devices described with respect to FIGS. **1** and **22**.

The electronic device **600***b* also includes a display assembly positioned under the front cover **652***b* (as previously shown in FIG. **1**). The display assembly in turn includes an antenna element, that may be a resonating antenna element, of a wireless communication system. The display assembly and its antenna element may be as shown and described with respect to the display assembly **172** and the first antenna element **278** and that description is not repeated here.

The housing **610***b* includes a conductive upper portion **612***b* and a conductive lower portion **614***b*. The housing **610***b* also includes two conductive bridge portions as described below. The housing **610***b* also defines a slot **630***b*, and a dielectric portion **634***b* of the housing **610***b* is positioned within the slot **630***b*. The housing **610***a* also defines a slot **631***b*, and a dielectric portion **635***b* of the housing **610***b* is positioned within the slot **631***b*. In embodiments, the conductive upper portion **612***b* defines one or more antenna elements, that may be resonating antenna elements, of the wireless communication system. The antenna element of the display assembly may be operatively coupled to the antenna element(s) of the housing **610***b*. For example, the display antenna element may be conductively coupled to the housing antenna element(s). In further embodiments, each of the slots **630***b* and **631***b* are configured to operate as a radiating element of the wireless communication system. The additional description provided with respect to the housings **110**, **210***a*, and **210***b* is applicable to the housing **610***a* and is not repeated here.

As shown in FIG. **6**B, the housing **610***b* includes four sides **606***b*, **607***b*, **608***b*, and **609***b*. In the view of FIG. **6**A, the dielectric portion **634***b* (and the slot **630***b*) is located on a first region of the side **606***b*, on the side **607***b*, and on a first region of the side **608***b*. The dielectric portion **635***b* (and the slot **631***b*) is located on a second region of the side **606***b*, on the side **609***b*, and on a second region of the side **608***b*. The bridge portions **618***b* and **619***b* are respectively positioned on the sides **606***b* and **608***b*. The side **608***b* may be generally opposite the side **606***b* and the side **609***b* may be generally opposite the side **607***b*.

The feed **692***b* is positioned centrally along the side **607***b* of the housing, while the feed **693***b* is positioned centrally along the side **609***b* of the housing **610***a*. Each of the feeds **692***b* and **693***b* may transmit a positive antenna signal to and/or may receive a positive antenna signal from the wireless communication system. In some embodiments, the upper portion **612***b* defines an antenna element along the side **607***b* and the upper portion **612***b* defines an additional antenna element along the side **609***b* of the housing. In some cases, the feed **692***b* may transmit a positive antenna signal (and/or may receive an antenna signal from) the housing antenna element along the side **607***b*. In these cases, the feed **693***b* may transmit a positive antenna signal (and/or may receive an antenna signal from) the housing antenna element along the side **609***b*. The additional description of conductive coupling between the display and housing antenna elements provided with respect to FIGS. **1**, **4**B, and **9** to **15** is generally applicable herein and is not repeated here.

As schematically shown in FIG. **6**B, the ground **694***b* is positioned along and conductively coupled to the side **606***b* of the housing **610***b* (between the dielectric portions **634***b* and **635***b*). The ground **695***b* is positioned along and conductively coupled to the side **608***b* of the housing **610***b* (between the dielectric portions **634***b* and **635***b*). The ground **696***b* extends between the sides **606***b* and **608***b* of the housing **610***b* and along a central portion of the display assembly.

FIG. **7**A shows a view of another example electronic device. The electronic device **700***a* includes a housing **710***a* and a front cover **752***a* coupled to the housing. The electronic device also includes a wireless communication system and additional elements of the wireless communication system are discussed in more detail below. The electronic device **700***a* also includes an input device **703***a* and a band **760**. The front cover **752***a* may be similar to the front cover **152**, the input device **703***a* may be similar to the input device **103**, and the band **760** may be similar to the band **160**.

The electronic device **700***a* also includes a display assembly positioned under the front cover **752***a* (as previously shown in FIG. **1**). The display assembly in turn includes an antenna element, that may be a resonating antenna element, of a wireless communication system. The display assembly and its antenna element may be as shown and described with respect to the display assembly **172** and the first antenna element **278** and that description is not repeated here.

The housing **710***a* includes a conductive upper portion **712***a* and a conductive lower portion **714***a*. The housing **710***a* also includes two conductive bridge portions as described below. The housing **710***a* also defines a slot **730***a* and a dielectric portion **734***a* of the housing **710***a* is positioned within the slot **730***a*. The housing **710***a* also defines a slot **731***a*, and a dielectric portion **735***a* of the housing **710***a* is positioned within the slot **731***a*. In embodiments, the conductive upper portion **712***a* defines one or more antenna elements, that may be one or more resonating antenna elements, of the wireless communication system. The antenna element of the display assembly may be operatively coupled to the antenna element(s) of the housing **710***a*. For example, the display antenna element may be conductively coupled to the housing antenna element(s). In embodiments, connections between the display assembly and the upper portion of the housing are made at a plurality of discrete locations, such as from 2 to 10 locations, from 3 to 10 locations, from 4 to 10 locations, or from 4 to 8 locations. In further embodiments, each of the slots **730***a* and **731***a* is configured to operate as a radiating element of the wireless communication system. The additional description provided with respect to the housings **110**, **210***a*, and **210***b* is applicable to the housing **710***a* and is not repeated here. FIGS. **7**B and **7**C give examples of how one or more feeds and one or more grounds may be incorporated into the electronic device **700***a*.

As shown in FIG. **7**A, the housing **710***a* includes four sides **706***a*, **707***a*, **708***a*, and **709***a*. The view of FIG. **7**A shows a conductive bridge portion **719***a* on the side **708***a*; another conductive bridge portion is present on the side **706***a* as shown in the top view of FIG. **7**B. As previously discussed with respect to FIGS. **1-3**, the upper portion **712***a*, the lower portion **714**a, and the bridge portions **718**a and **719**a of the housing **710**a may be formed of a single piece of conductive material. As shown in FIG. **7**A, the bridge portions **718**a and **719**a are longer than those shown in FIGS. **5**B and **6**B. In the view of FIG. **7**A, the dielectric portion **734**a (and the slot **730**a) is located on a first region of the side **706**a, on the side **707**a, and on a first region of the side **708**a. The dielectric portion **735**a (and the slot **731**a) is located on a second region of the side **706**a, on the side **709**a, and on a second region of the side **708**a. The side **708**a may be generally opposite the side **706**a and the side **709**a may be generally opposite the side **707**a.

FIG. **7**B shows a top view of an example electronic device, which may be an example of the device of FIG. **7**A. The electronic device **700**b includes a housing **710**b and a front cover **752**b coupled to the housing. The electronic device also includes a wireless communication system. A feed **792**b, a ground **794**b, and an optional switchable ground **795**b of the wireless communication system are schematically illustrated in FIG. **7**B and additional elements of the wireless communication system are discussed in more detail below. The electronic device **700**b also includes an input device **703**b and an input device **705**b. The front cover **752**b may be similar to the front cover **152**, the input device **703**b may be similar to the input device **103** and the input device **705**b may be any of the input devices described with respect to FIGS. **1** and **22**.

The electronic device **700**b also includes a display assembly positioned under the front cover **752**b (as previously shown in FIG. **1**). The display assembly in turn includes an antenna element, that may be a resonating antenna element, of a wireless communication system. The display assembly and its antenna element may be as shown and described with respect to the display assembly **172** and the first antenna element **278** and that description is not repeated here.

The housing **710**b includes a conductive upper portion **712**b and a conductive lower portion **714**b. The housing **710**b also includes two conductive bridge portions as described below. The housing **710**b also defines a slot **730**b, and a dielectric portion **734**b of the housing **710**b is positioned within the slot **730**b. The housing **710**a also defines a slot **731**b and a dielectric portion **735**b of the housing **710**b is positioned within the slot **731**b. In embodiments, the conductive upper portion **712**b defines one or more antenna elements, that may be one or more resonating antenna elements, of the wireless communication system. The antenna element of the display assembly may be operatively coupled to the antenna element(s) of the housing **710**b. For example, the display antenna element may be conductively coupled to the housing antenna element(s). In embodiments, connections between the display assembly and the upper portion of the housing are made at a plurality of discrete locations, such as from 2 to 10 locations, from 3 to 10 locations, from 4 to 10 locations, or from 4 to 8 locations. In further embodiments, each of the slots **730**b and **731**b is configured to operate as a radiating element of the wireless communication system. The additional description provided with respect to the housings **110**, **210**a, and **210**b is applicable to the housing **710**b and is not repeated here.

As shown in FIG. **7**B, the housing **710**b includes four sides **706**b, **707**b, **708**b, and **709**b. In the view of FIG. **7**B, the dielectric portion **734**b (and the slot **730**b) is located on a first region of the side **706**b, on the side **707**b, and on a first region of the side **708**b. The dielectric portion **735**b (and the slot **731**b) is located on a second region of the side **706**b, on the side **709**b, and on a second region of the side **708**b. The bridge portions **718**b and **719**b are respectively positioned on the sides **706**b and **708**b. The side **708**b may be generally opposite the side **706**b and the side **709**b may be generally opposite the side **707**b.

The feed **792**b is positioned away from the side **706**b and near a transition (e.g., a corner) between the sides **708**b and **709**b. The feed **792**b may transmit a positive antenna signal to and/or may receive a positive antenna signal from the wireless communication system. As previously described with respect to FIGS. **1** and **4**A, in some embodiments the feed **792**b is coupled to at least one of the first antenna element and the second antenna element. The additional description of conductive coupling between these two antenna elements provided with respect to FIGS. **1**, **4**A and **9** to **15** is generally applicable herein and is not repeated here.

As schematically shown in FIG. **7**B, the ground **794**b is positioned along the side **706**b (between the dielectric portions **734**b and **735**b). The ground **794**b is conductively coupled to the side **706**b of the housing **710**b and in some embodiments is conductively coupled to the lower portion **714**b. The switchable ground **795**b is positioned along the side **708**b and generally proximate the bridge **719**b. In some cases, the switchable ground is optional and if present may be operated as previously described with respect to FIG. **4**B.

FIG. **7**C shows a top view of an example electronic device, which may be an example of the device of FIG. **7**A. The electronic device **700**c includes a housing **710**c and a front cover **752**c coupled to the housing. A feed **792**c, a ground **794**c, and an optional switchable ground **795**c of the wireless communication system are schematically illustrated in FIG. **7**C. The electronic device **700**c also includes an input device **703**c and an input device **705**c. The front cover **752**c may be similar to the front cover **152**, the input device **703**c may be similar to the input device **103**, and the input device **705**c may be similar to any of the input devices described with respect to FIGS. **1** and **22**.

The electronic device **700**c also includes a display assembly positioned under the front cover **752**c (as previously shown in FIG. **1**). The display assembly in turn includes an antenna element, that may be a resonating antenna element, of a wireless communication system. The display assembly and its antenna element may be as shown and described with respect to the display assembly **172** and the first antenna element **278** and that description is not repeated here.

The housing **710**c may be similar to the housing **710**b. In embodiments, the conductive upper portion **712**c defines one or more antenna elements, that may be resonating antenna elements. In further embodiments, each of the slots **730**c and **731**c are configured to operate as a radiating element of the wireless communication system. The conductive upper portion **712**c, the conductive lower portion **714**c, the conductive bridge portions **718**c and **719**c, the slots **730**c and **731**c, the dielectric portions **734**c and **735**c, and the sides **706**c, **707**c, **708**c, and **709**c may be similar in form and materials to the conductive upper portion **712**b, the conductive lower portion **714**b, the conductive bridge portions **718**b and **719**b, the slots **730**b and **731**b, the dielectric portions **734**b and **735**b, and the sides **706**b, **707**b, **708**b, and **709**b and that description is not repeated here.

In embodiments, the antenna element of the display assembly is operatively coupled to the antenna element(s) of the housing **710**c. For example, the display antenna element may be conductively coupled to the housing antenna element(s) defined by the conductive upper portion **712**c. As previously discussed, these antenna elements may be conductively coupled by coupling a circuit assembly of the display assembly to a conductive upper portion of a housing.

The example of FIG. **7**C shows two connector components, **797***c* and **798***c*, used to connect the display assembly to the conductive upper portion **712***c*. In some cases, the connector components **797***c* and **798***c* connect a circuit assembly of the display assembly to the conductive upper portion **712***c*. The connector component **797***c* is positioned centrally along the side **707***c* while the connector component **798***c* is positioned centrally along the side **709***c* of the housing **710***c*. The electronic device **700***c* of FIG. **7**C may have a fewer number of connections between the display assembly and the housing **712***c* than the electronic devices **400***b*, **500***b*, **600***b*, and **700***b*. The position of the feed **792***c*, the ground **794***c*, and the switchable ground **795***c* may be similar to that of the feed **792***b*, the ground **794***b*, and the (optional) switchable ground **795***b*.

FIG. **8** shows a view of another example electronic device. The electronic device **800** includes an enclosure **805**. The enclosure includes a housing **810** and a front cover **852**. The front cover **852** is positioned over a display assembly **872** (indicated with a dashed line). The enclosure may also include a rear cover, which may be similar to that shown in the cross-section view of FIG. **2**A. The rear cover may be positioned over a sensing panel as previously discussed with respect to FIG. **2**A. The device **800** defines a front surface **802**, a rear surface **804**, and a side surface **806**. In the example of FIG. **8**, the device **800** defines four sides, each of which may partially define the side surface **806**.

The housing **810** includes a lower portion **814** and an upper dielectric portion **846**. In embodiments, the lower portion **814** is conductive. As shown in FIG. **8**, the upper dielectric portion **846** extends around a periphery of the housing **810** and along all four sides (and corners). The lower portion **814** may be formed of similar materials as previously described for the lower portion **114**, and the upper dielectric portion **846** may be formed of similar materials as previously described for the dielectric portion **134** of FIG. **1** and those details are not repeated here.

The display assembly **872** may comprise an antenna element, also referred to as a display antenna element. During operation of the electronic device **800**, the lower portion **814** of the housing **810** may be connected to an electrical ground and the display antenna element may be conductively coupled to a feed terminal. The upper dielectric portion **846** of the housing **810** can allow for greater separation between the display antenna element and the grounded lower portion **814** of the housing **810** as compared to a wholly conductive housing having a shape similar to that of the housing **810**. In some cases, using a housing **810** having an upper dielectric portion **846**, rather than a conductive housing, can maintain the performance of the display antenna element and/or allow use of a display assembly having a larger lateral dimension.

The electronic device **800** may include a feed for the display antenna and a ground. In some cases, the feed and the ground may be positioned similarly to the feed and ground positions shown in the examples of FIGS. **5**B and **7**B. In some cases, the electronic device also includes a switchable ground, and the switchable ground may also be positioned and operated similarly to the switchable ground positions shown in the examples of FIGS. **5**B and FIG. **7**B.

The electronic device also includes an input device **803**, which may be a dial having an outer surface configured to receive a rotary input. A band **860** is attached to the housing **810** and configured to secure the electronic device **800** to a user. The cover **852** may be similar to the cover **152**, the display **872** may be similar to the display **172**, and the input device **803** may be similar to the input device **103** and that description is not repeated here.

FIG. **9** shows an exploded view of several elements of an example electronic device. In the example of FIG. **9**, the connector element **986** and the connector element **988** are used to conductively couple the housing **910** to a circuit assembly **973** of the electronic device **900**. The circuit assembly **973** may be part of a display assembly. The electronic device also includes input devices **903** and **905** and a band **960** configured to secure the electronic device **900** to a user. FIGS. **10**A and **10**B show examples of partial cross-sectional views of the device **900**; these cross-sectional views show additional device elements such as the display assembly and the display cover.

The housing **910** includes an upper portion **912**, a lower portion **914**, and a dielectric portion **934**. In embodiments, each of the upper portion **912** and the lower portion **914** is conductive (and may also be referred to as an upper conductive portion **912** and a lower conductive portion **914**). The dielectric portion **934** is positioned within a slot **930** and the slot is positioned along a side surface **906** of the electronic device **900**. In embodiments, the housing **910** defines an antenna element and the slot **930** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The antenna element defined by the housing may also be referred to herein as a housing antenna element.

The electronic device **900** also includes a circuit assembly **973** of a display assembly. The circuit assembly **973** may include a display antenna element, as previously discussed with respect to FIGS. **1** and **2**A-**2**B. The circuit assembly may include one or more conductive structures formed on a dielectric substrate. For example, the conductive structures may include conductive structures configured to operate as an antenna element. The conductive structures may be provided on a dielectric substrate of the circuit assembly. For example, the dielectric substrate may be a circuit board and the conductive structures may be printed on the circuit board. In some cases, other components may be included in the circuit assembly, such as an element configured to provide a feed signal to one or more antenna elements. Other parts of the display assembly, as well as a cover over the display assembly are shown in the cross-sectional views of FIGS. **10**A and **10**B.

The connector element **988** is configured to contact one or more locations on an interior surface of the upper portion **912** of the housing **910**. The connector element **988** has the form of a ring that defines a gap. The connector element **988** is also configured to contact one or more locations of the connector **986**. For example, the connector element **988** may be shaped to have slight variations in the inside and the outside diameter of the ring to allow some portions of the ring to contact the upper portion **912** of the housing and other portions of the ring to contact the connector element **986**, as illustrated in the cross-sectional views of FIGS. **10**A and **10**B. Therefore, the connector component **988** may have a "wavy" profile as viewed from that top so that it can (alternately) contact both the upper portion **912** of the housing **910** and the circuit assembly **973** (through the connector element **986**). The connector component **988** may be spring loaded to maintain contact. In the example of FIG. **9**, the gap is positioned on a side of the housing **910** opposite the input device **903**. The connector element **988** may include or be formed of a conductive material, such as a metal or metal alloy, to provide conductive coupling of the upper portion **912** and the connector element **986**.

The connector element **986** is configured to allow conductive coupling between the connector element **986** and the circuit assembly **973** or other parts of the display assembly. In some embodiments, the connector element **986** may include one or more tab features. For example, the tab feature **985***b*, which has a substantially horizontal orientation, can be used to conductively couple the connector element **986** and the display assembly as shown in the example of FIG. **10**B. In addition, the connector element **986** is configured to allow conductive coupling between the connector element **986** and the connector element **988**. For example, the tab feature **985***a*, which has a substantially vertical orientation, can be used to conductively couple the connector element **986** and the connector element **988** as shown in the example of FIG. **10**A. The number and position of the tab features **985***a* and **985***b* shown in FIG. **9** is exemplary rather than limiting and in additional examples the tab features may be different in number and/or positioned differently than shown in FIG. **9**. As shown in FIG. **9**, the connector element **986** also has the form of a ring defining a gap, with the gap positioned on the same side of the housing as the input device **903**. The connector element **986** may include or be formed of a conductive material, such as a metal or metal alloy, to provide conductive coupling to the connector element **988**.

FIG. **10**A shows an example of a partial cross-sectional view of an electronic device. The electronic device **1000***a* may be an example cross-section of the electronic device **900** of FIG. **9**. The electronic device **1000***a* includes a housing **1010***a*, a display assembly **1072***a* positioned within the housing, and a front cover **1052***a* positioned over the display assembly **1072***a*.

The housing **1010***a* includes a conductive upper portion **1012***a*, a conductive lower portion **1014***a*, and a dielectric portion **1034***a*. The dielectric portion **1034***a* is positioned within a slot **1030***a*. The slot **1030***a* is defined by a surface **1023***a* of the upper portion **1012***a* and by a surface **1025***a* of the lower portion **1014***a* in a similar fashion as previously described with respect to FIGS. **2**A and **2**B. The surfaces **1023***a* and **1025***a* may define a minimum or average minimum gap height as previously described with respect to FIGS. **2**A and **2**B. In embodiments, the upper portion **1012***a* of the housing **1010***a* defines an antenna element and the slot **1030***a* is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The antenna element defined by the housing may also be referred to herein as a housing antenna element. The lower portion **1014***a* defines a ledge **1016***a* that supports the cover **1052***a* and the display assembly **1072***a* as described in more detail below.

As previously described with respect to FIG. **1**, the upper **1012***a* and/or the lower portion **1014***a* of the housing **1010***a* may be configured to define one or more retention features. These retention features can allow one or more structural interlocks to be formed between the dielectric component **1034***a* and the upper **1012***a* and/or the lower portion **1014***a* of the housing **1010***a*. As shown in the example of FIG. **10**A, the lower portion **1014***a* of the housing **1010***a* defines several retention features. For example, the lower portion **1014***a* defines a retention feature **1029***a* in the form of a protrusion at a peripheral region of the surface **1025***a*. The lower portion **1014***a* also defines an opening **1039***a* which provides an interlock between the dielectric component **1034***a* and the lower portion **1014***a*.

The display assembly **1072***a* includes an element **1076***a*, which in some cases may be a display control circuit. In some cases, the display control circuit may be provided on a circuit assembly as previously described (e.g., **973**). In additional cases, the element **1076***a* may include a feed terminal, which may be part of the circuit assembly. The display assembly typically also includes one or more display components such as a pixel definition layer, a touch sensitive layer and the like. As shown in FIG. **10**A, a periphery of the display assembly **1072***a* is at least partially surrounded by a display frame **1058***a*. A periphery of the front cover **1052***a* is surrounded by a cover frame **1056***a*. Each of the display frame **1058***a* and the cover frame **1056***a* may be formed from or may include a dielectric material, such as a polymer material or a polymer matrix composite. The display frame **1058***a* may be coupled to the ledge **1016***a*, such as with an adhesive. The cover frame **1056***a* may be coupled to the display frame **1058***a* by directly bonding the dielectric materials of the two frames or by coupling the two frames with an adhesive.

In the view of FIG. **10**A, the connector component **1088***a* is positioned so that it contacts and is conductively coupled to the upper portion **1012***a* of the housing **1010***a*. The component **1088***a* does not contact any elements of the display assembly **1072***a* in the plane of this cross-section. As previously described with respect to the connector component **988**, the connector component **1088***a* may have a "wavy" profile as viewed from that top so that it can (alternately) contact both the upper portion **1012***a* of the housing and the display assembly **1072***a*. The connector component **1088***a* may be spring loaded to maintain contact. The connector component **1088***a* may be formed of similar materials as those previously described for the connector component **988**. Additional details provided with respect to the geometry of the connector component **988** are generally applicable herein.

FIG. **10**B shows an example of a partial cross-sectional view of an electronic device. The electronic device **1000***b* may be another example cross-section of the electronic device **900** of FIG. **9**. The electronic device **1000***b* includes a housing **1010***b*, a display assembly **1072***b* positioned within the housing, and a front cover **1052***b* positioned over the display assembly **1072***b*. The housing **1010***b*, the display assembly **1072***b*, the element **1076***b*, the front cover **1052***b*, the frames **1056***b* and **1058***b*, and the connector **1088***b* may be the same as or similar to the housing **1010***a*, a display assembly **1072***a*, the element **1076***a*, the front cover **1052***a*, the frames **1056***a* and **1058***a*, and the connector **1088***a*.

The housing **1010***b* includes a conductive upper portion **1012***b*, a conductive lower portion **1014***b*, and a dielectric portion **1034***b*. The dielectric portion **1034***b* is positioned within a slot **1030***b*. The slot **1030***b* is defined by a surface **1023***b* of the upper portion **1012***b* and by a surface **1025***b* of the lower portion **1014***b* in a similar fashion as previously described with respect to FIGS. **2**A and **2**B. The surfaces **1023***b* and **1025***b* may define a minimum or average minimum gap height as previously described with respect to FIGS. **2**A and **2**B. In embodiments, the upper portion **1012***b* of the housing **1010***b* defines an antenna element and the slot **1030***b* is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The antenna element defined by the housing may also be referred to herein as a housing antenna element. The lower portion **1014***b* defines a ledge **1016***b* that supports the cover **1052***b* and the display assembly **1072***b* as described in more detail below.

As previously described with respect to FIGS. **1** and **10**A, the upper **1012***b* and/or the lower portion **1014***b* of the housing **1010***b* may be configured to define one or more retention features. As shown in the example of FIG. **10**B, the housing **1010***b* defines several retention features. For example, the upper portion **1012***b* defines a recess **1028***b* which provides an interlock between the dielectric component **1034***b* and the upper portion **1012***b*. The lower portion **1014***b* defines a protruding retention feature **1029***b* which is similar to the retention feature **1029***a* described with respect to FIG. **10**A.

The display assembly **1072***b* includes an element **1076***b*. The display assembly **1072***b* and the element **1076***b* may be as previously described for the display assembly **1072***a* and the element **1076***a* and that description is not repeated here. A periphery of the display assembly **1072***b* may be at least partially surrounded by a display frame **1058***b*. A periphery of the front cover **1052***b* may be surrounded by a cover frame **1056***b*. Each of the display frame **1058***b* and the cover frame **1056***b* may be formed from or may include a dielectric material, such as a polymer material or a polymer matrix composite. The display frame **1058***b* may be coupled to the ledge **1016***b*, such as with an adhesive. The cover frame **1056***b* may be coupled to the display frame **1058***b* by directly bonding the dielectric materials of the two frames or by coupling the two frames with an adhesive.

As shown in FIG. **10**B, the connector component **1088***b* is positioned so that it contacts and is conductively coupled to the connector component **1086***b* (this connector component is not visible in the cross-section of FIG. **10**A). However, the connector component **1088***b* does not contact the upper portion **1012***a* of the housing **1010***a* in the plane of this cross-section. The connector component **1086***b* passes through the display frame **1058***b* and is conductively coupled to the element **1076***b* by the connector component **1087***b*. For example, the connector component **1086***b* may be conductively coupled to the display assembly **1072***b* by a conductive adhesive, by solder, or the like. The connector components **1086***b* and **1088***b* may be formed of similar materials as those previously described for the connector components **986** and **988**. The connector component **1087***b* may be formed from or include a conductive material such as a metal or metal alloy and may be flexible. For example, the connector component **1087***b* may be a metallic wire, strip, or tape. The connector component **1086***b* may be configured to be more rigid than the connector component **1087***b*.

FIG. **11** shows another example of a partial cross-sectional view of an electronic device. The electronic device **1100** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic device of any one of FIGS. **4**A through **7**C. The electronic device **1100** includes a housing **1110**, a display assembly **1172** positioned within the housing, and a front cover **1152** positioned over the display assembly **1172**.

The housing **1110** includes an upper conductive portion **1112**, a lower conductive portion **1114**, and a dielectric portion **1134**. The dielectric portion **1134** is positioned within a slot **1130**. The slot **1130** is defined by a surface **1123** of the upper portion **1112** and by a surface **1125** of the lower portion **1114** in a similar fashion as previously described with respect to FIGS. **2**A and **2**B. The surfaces **1123** and **1125** may define a minimum or average minimum gap height as previously described with respect to FIGS. **2**A and **2**B. In embodiments, the upper portion **1112** of the housing **1110** defines an antenna element and the slot **1130** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The antenna element defined by the housing may also be referred to herein as a housing antenna element. The lower portion **1114** defines a ledge **1116** that supports the cover **1152** and the display assembly **1172**.

In the example of FIG. **11**, periphery of the display assembly **1172** is surrounded by a display frame **1158**. The display frame **1158** may be formed from or may include a dielectric material, such as a polymer material or a polymer matrix composite. The display frame **1158** may be coupled to the ledge **1116**, such as with an adhesive.

As shown in FIG. **11**, the connector component **1189** is positioned so that it contacts and is conductively coupled to the upper portion **1112** of the housing **1110**. In some cases, the connector component **1189** may be formed from a conductive adhesive. The connector component **1185** is positioned so that it contacts and is conductively coupled to the connector component **1189** and also contacts a side surface and a rear surface of the front cover **1152**. In some cases, the connector component **1185** is formed from a thin layer of conductive material, such as a metal or metal alloy, deposited on the side and rear surfaces of the front cover **1152**. As shown in FIG. **11**, the connector component **1185** contacts a front surface of the display assembly **1172**. If it is desirable to conductively couple the connector component **1185** with a component (e.g., a circuit assembly) positioned within an interior of or at a rear surface of the display assembly, an additional connector such as a via can be included in the electronic device.

FIG. **12** shows another example of a partial cross-sectional view of an electronic device. The electronic device **1200** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic device of any one of FIGS. **4**A through **7**C. The electronic device **1200** includes a housing **1210**, a display assembly **1272** positioned within the housing **1210**, and a front cover **1252** positioned over the display assembly **1272**.

The housing **1210** includes a conductive upper portion **1212**, a conductive lower portion **1214**, and a dielectric portion **1234**. The dielectric portion **1234** is positioned within a slot **1230**. The slot **1230** is defined by a surface **1223** of the upper portion **1212** and by a surface **1225** of the lower portion **1214** in a similar fashion as previously described with respect to FIGS. **2**A and **2**B. The surfaces **1223** and **1225** may define a minimum or average minimum gap height as previously described with respect to FIGS. **2**A and **2**B. In embodiments, the upper portion **1212** of the housing **1210** defines an antenna element and the slot **1230** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The antenna element defined by the housing may also be referred to herein as a housing antenna element. The lower portion **1214** defines a ledge **1216** that supports the cover **1252** and the display assembly **1272**.

In the example of FIG. **12**, the display assembly **1272** includes an element **1276**. The element **1276** may be similar to the elements **1076***a*, **1076***b* and that description is not repeated here. As shown in FIG. **12**, a periphery of the display assembly **1272** is at least partially surrounded by a display frame **1258** and a periphery of the front cover **1252** is surrounded by a cover frame **1256**. Each of the display frame **1258** and the cover frame **1256** may be formed from or may include a dielectric material, such as a polymer material or a polymer matrix composite. The display frame **1258** may be coupled to the ledge **1216**, such as with an adhesive. The cover frame **1256** may be coupled to the display frame **1258** by directly bonding the dielectric materials of the two frames or by coupling the two frames with an adhesive.

As shown in FIG. **12**, the connector component **1286** is positioned so that it contacts and is conductively coupled to the upper portion **1212** of the housing **1210**. The connector component **1286** also passes through the display frame **1258** and is conductively coupled to the element **1276**. The connector element **1286** may include or be formed of a conductive material, such as a metal or metal alloy. In some cases, an end of the connector element **1286** may define a spring contact (e.g., at the upper portion **1212**).

FIG. **13** shows another example of a partial cross-sectional view of an electronic device. The electronic device **1300** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic device of any one of FIGS. **4**A through **7**C. The electronic device **1300** includes a housing **1310**, a display assembly **1372** positioned within the housing, and a front cover **1352** positioned over the display assembly **1372**.

The housing **1310** includes a conductive upper portion **1312**, a conductive lower portion **1314**, and a dielectric portion **1334**. The dielectric portion **1334** is positioned within a slot **1330**. The slot **1330** is defined by a surface **1323** of the upper portion **1312** and by a surface **1325** of the lower portion **1314** in a similar fashion as previously described with respect to FIGS. **2**A and **2**B. The surfaces **1323** and **1325** may define a minimum or average minimum gap height as previously described with respect to FIGS. **2**A and **2**B. In embodiments, the upper portion **1312** of the housing **1310** defines an antenna element and the slot **1330** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The antenna element defined by the housing may also be referred to herein as a housing antenna element. The upper portion **1312** defines a ledge **1316** that supports the cover **1352** and the display assembly **1372**. As compared to the examples of FIGS. **10**A through **12**, the surface **1323** is at a lower position with respect to a top surface of the upper portion **1312**.

As previously described with respect to FIG. **1**, the upper **1312** and/or the lower portion **1314** of the housing **1310** may be configured to define one or more retention features. These retention features can allow one or more structural interlocks to be formed between the dielectric component **1334** and the upper **1312** and/or the lower portion **1314** of the housing **1310**. As shown in the example of FIG. **13**, the surface **1323** of the upper portion **1312** and the surface **1325** of the lower portion **1314** each define depressions (e.g., **1329**) that can act as a retention feature.

In the example of FIG. **13**, a periphery of the display assembly **1372** is surrounded by a display frame **1358**. The display frame **1358** may be formed from or may include a dielectric material, such as a polymer material or a polymer matrix composite. The display frame **1358** may be coupled to the ledge **1316**, such as with an adhesive.

As shown in FIG. **13**, the connector component **1387** is positioned so that it contacts and is conductively coupled to ledge **1316** defined by the upper portion **1312** of the housing **1310**. The connector component **1387** is also conductively coupled to the display assembly **1372** and in some cases may be conductively coupled to a circuit assembly of the display assembly **1372**, as previously discussed with respect to FIGS. **10**A, **10**B, and **12**. The connector component **1387** may be formed of a conductive material such as a metal or metal alloy. In some cases, the connector component **1387** may define a metallic spring finger.

FIG. **14** shows another example of a partial cross-sectional view of an electronic device. The electronic device **1400** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic device of any one of FIGS. **4**A through **7**C. The electronic device **1400** includes a housing **1410**, a display assembly **1472** positioned within the housing, and a front cover **1452** positioned over the display assembly **1472**.

The housing **1410** includes a conductive upper portion **1412**, a conductive lower portion **1414**, and a dielectric portion **1434**. The dielectric portion **1434** is positioned within a slot **1430**. The slot **1430** is defined by a surface **1423** of the upper portion **1412** and by a surface **1425** of the lower portion **1414** in a similar fashion as previously described with respect to FIGS. **2**A and **2**B. The surfaces **1423** and **1425** may define a minimum or average minimum gap height as previously described with respect to FIGS. **2**A and **2**B. In embodiments, the upper portion **1412** of the housing **1410** defines an antenna element and the slot **1430** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The antenna element defined by the housing may also be referred to herein as a housing antenna element. The upper portion **1412** defines a ledge **1416** that supports the cover **1452** and the display assembly **1472**. As compared to the examples of FIGS. **10**A through **12**, the surface **1423** is at a lower position with respect to a top surface of the upper portion **1412**.

As previously described with respect to FIG. **1**, the upper **1412** and/or the lower portion **1414** of the housing **1410** may be configured to define one or more retention features. These retention features can allow one or more structural interlocks to be formed between the dielectric component **1434** and the upper **1412** and/or the lower portion **1414** of the housing **1410**. As shown in the example of FIG. **14**, the surface **1423** of the upper portion **1412** of the housing **1410** defines a step that can act as a retention feature. The surface **1425** of the lower portion **1414** defines an angled feature **1429** that can act as a retention feature as well as a smaller step.

In the example of FIG. **14**, a periphery of the display assembly **1472** may be surrounded by a display frame **1458**. The display frame **1458** may be formed from or may include a dielectric material, such as a polymer material or a polymer matrix composite. The display frame **1458** may be coupled to the ledge **1416**, such as with an adhesive.

As shown in FIG. **14**, the connector component **1487** is positioned so that it contacts and is conductively coupled to the ledge **1416** defined by the upper portion **1412** of the housing **1410**. For example, the connector component **1487** may be conductively coupled to the ledge **1416** by a conductive adhesive, by soldering, by laser welding, or the like. The connector component **1487** is also conductively coupled to the display assembly **1472** and in some cases may be conductively coupled to a circuit assembly of the display assembly **1472**, as previously discussed with respect to FIGS. **10**A, **10**B, and **12**. For example, the connector component **1487** may be conductively coupled to the display assembly **1472** by a conductive adhesive, by solder, or the like. The connector component **1487** may be formed of a conductive material such as a metal or metal alloy and may be flexible. For example, the connector component **1487** may be a metallic wire or strip.

FIG. **15** shows another example of a partial cross-sectional view of an electronic device. The electronic device **1500** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic devices of any one of FIGS. **4**A through **7**C. The electronic device **1500** includes a housing **1510**, a display assembly **1572** positioned within the housing, and a front cover **1552** positioned over the display assembly **1572**.

The housing **1510** includes a conductive upper portion **1512**, a conductive lower portion **1514**, and a dielectric portion **1534**. The dielectric portion **1534** is positioned within a slot **1530**. The slot **1530** is defined by a surface **1523** of the upper portion **1512** and by a surface **1525** of the lower portion **1514** in a similar fashion as previously described with respect to FIGS. **2**A and **2**B. The surfaces **1523** and **1525** may define a minimum or average minimum gap height as previously described with respect to FIGS. **2**A and **2**B. In embodiments, the upper portion **1512** of the housing **1510** defines an antenna element and the slot **1530** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The antenna element defined by the housing may also be referred to herein as a housing antenna element. The upper portion **1512** defines a ledge **1516** that supports the display assembly **1572**. As compared to the examples of FIGS. **10**A through **12**, the surface **1523** is at a lower position with respect to a top surface of the upper portion **1512**.

As previously described with respect to FIG. **1**, the upper **1512** and/or the lower portion **1514** of the housing **1510** may be configured to define one or more retention features. These retention features can allow one or more structural interlocks to be formed between the dielectric component **1534** and the upper **1512** and/or the lower portion **1514** of the housing **1510**. As shown in the example of FIG. **15**, the surface **1523** of the upper portion **1512** of the housing **1510** defines a step that can act as a retention feature. The surface **1525** of the lower portion **1514** defines an angled feature **1529** that can act as a retention feature as well as a smaller step.

In the example of FIG. **15**, a periphery of the display assembly **1572** is surrounded by a display frame **1558**. The display frame **1558** may be formed from or may include a dielectric material, such as a polymer material or a polymer matrix composite. The display frame **1558** may be coupled to the ledge **1516**, such as with a seal **1554**.

As shown in FIG. **15**, the connector component **1585** is positioned so that it passes through the seal **1554** and then conforms to a side surface of the display frame **1558**. The connector component **1585** may be conductively coupled to an interior surface of the upper portion **1512** of the housing **1510** by a conductive adhesive, a spring contact, or the like. The connector component **1585** is also conductively coupled to the display assembly **1572** and in some cases may be conductively coupled to a circuit assembly of the display assembly **1572**, as previously discussed with respect to FIGS. **10**A, **10**B, and **12**. For example, the connector component **1585** may be conductively coupled to the display assembly **1572** by a conductive adhesive, by solder, or the like. The connector component **1585** may be formed of a conductive material such as a metal or metal alloy and may be sufficiently flexible to conform to a side surface of the display frame **1558** after passing through the seal **1554**.

FIG. **16** shows another example of a partial cross-sectional view of an electronic device. The electronic device **1600** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic devices of any one of FIGS. **4**A through **7**C. The electronic device **1600** includes a housing **1610**, a display assembly **1672** positioned within the housing, and a front cover **1652** positioned over the display assembly **1672**.

The housing **1610** includes a conductive upper portion **1612**, a conductive lower portion **1614**, and a dielectric portion **1634**. The dielectric portion **1634** is positioned within a slot **1630**. The slot **1630** is defined at least in part by a surface **1623** of the upper portion **1612** and by a surface **1625** of the lower portion **1614**. In embodiments, the upper portion **1612** of the housing **1610** defines at least a portion of an antenna element and the slot **1630** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The housing **1610**, the conductive upper portion **1612**, the conductive lower portion **1614**, the dielectric portion **1634**, and the slot **1630** may be formed of similar materials as the housing **110**, the conductive upper portion **112**, the conductive lower portion **114**, the dielectric portion **134**, and the slot **130** and that description is not repeated here.

In the example of FIG. **16**, an electrically insulating element **1607** is disposed over an interior surface region **1627** of the lower portion **1614** of the housing **1610**. The electrically insulating element **1607** also defines a bottom of the gap **1683**. As previously discussed, the electrically insulating element **1607** may ensure consistent and reliable operation of the antenna by providing an additional layer of non-conductive material, such as a dielectric material, within a void or gap in the enclosure in which an ingress of fluid may enter and become trapped. The electrically insulating element **1607** may maintain sufficient isolation between conductive and non-conductive components in order to ensure consistent or acceptable operation of the antenna. In some cases, the electrically insulating element **1607** may restrict or prevent an unintended current in case a conducting fluid enters the gap **1683**. One example of a conducting fluid is an aqueous fluid including dissolved ions, such as saltwater. The description provided herein of using a layer or other form of non-conductive material to ensure consistent and reliable operation of the antenna is not limited to the example of FIG. **16** but applies more generally to other electronic devices described herein.

The electrically insulating element **1607** may be configured to limit ingress of a fluid that may be present within the gap **1683** towards the interior surface region **1627**. For example, the electrically insulating element **1607** may be substantially non-porous and may also be configured to inhibit significant diffusion of the fluid and/or its ions through the electrically insulating element (e.g., the electrically insulating element **1607** may be waterproof). Suitable materials for the electrically insulating element **1607** include, but are not limited to, polymer materials and polymer composite materials, such as epoxy-based materials and composite materials having an epoxy-based matrix. In some cases, the electrically insulating element **1607** may be formed from a thermosetting resin adhesive (e.g., an epoxy-based resin adhesive). In some cases, the electrically insulating element **1607** may be bonded to interior surface region **1627**. The bonding of the electrically insulating element **1607** to the interior surface region **1627** may be enhanced by surface modification of the interior surface region and/or formation of one or more retention features (also referred to as interlock features) on the interior surface region **1627**. In the example of FIG. **16**, the electrically insulating element **1607** extends under the dielectric portion **1634**. Therefore, the electrically insulating element **1607** also helps to limit ingress of a fluid that may be present within the gap **1683** towards the surface **1625** that defines the slot **1630**.

The electrically insulating element **1607** can thus reduce or prevent a current along an unintended path between the lower portion **1614** of the housing and the upper portion **1612** and/or the connector **1686** when a conducting fluid is present within the gap **1683**. In some cases, the reduction or prevention of a current along an unintended path between the lower portion **1614** and the upper portion **1612** and/or the connector **1686** can maintain the performance of the wireless communication system when a conducting fluid is present within the gap **1683**. As shown in FIG. **16**, the electrically insulating element **1607** may have a thickness T_{16} that is sufficient to provide the desired electrical isolation between any trapped fluid and the conductive material of the lower portion **1614**.

In the example of FIG. **16**, at least a portion of the interior surface region **1627** is recessed with respect to the region of the surface **1625** that defines the slot. In some cases, the electrically insulating element **1607** may be molded within a recess **1681** defined by the interior surface region **1627**. For example, a curable polymer resin may be disposed within the recess **1681** and then cured to form the electrically conducting element. In some cases, the electrically conducting element is substantially rigid after curing and a machining process, a grinding process, or the like may be used to further adjust the shape of the cured electrically conducting element.

As shown in FIG. **16**, a periphery of the display assembly **1672** is at least partially surrounded by a display frame **1658**. The electrically insulating element **1607** supports the display frame **1658** as well as the front cover **1652**. For example, the electrically insulating element **1607** may be coupled to the display frame **1658** by a coupling element **1609**, which may be an adhesive layer. The electrically insulating element **1607** may have a machined surface or other dimensionally stable surface **1638** that is used to mount the coupling element **1609** and ensure a consistent display stack position within the device **1600**. The display frame **1658** may be formed from or may include a dielectric material, such as a polymer material or a polymer matrix composite. In some embodiments, the display frame **1658** may be assembled from multiple components. The front cover **1652** may be coupled to the display frame **1658** with an adhesive. In additional examples, a periphery of the front cover **1652** may be at least partially surrounded by a cover frame, examples of which were previously shown in FIGS. **10**A, **10**B, and **12**. The display assembly **1672** and the front cover **1652** may be similar in function and materials to the display assembly **172** and the front cover **152**.

The electronic device **1600** includes a connector component **1686** that passes through the display frame **1658** and is conductively coupled to display assembly. For example, the connector component **1686** may be conductively coupled to the display assembly **1672** by a conductive adhesive, by solder, or the like. In some cases, the display assembly may include a display control circuit and the connector component **1686** may be conductively coupled to the display control circuit as previously discussed with respect to FIG. **12**. The connector component **1686** may be formed of similar materials as those previously described for the connector components **986** and **988**.

In some embodiments, the electronic device **1600** includes an additional connector component **1688** which may be similar in at least some aspects to the conductor component **988**. The connector component **1688** is shown with dashed lines in FIG. **16** to represent a volume of the gap **1683** which may be occupied by the connector component **1688**. The connector component **1688** does not completely fill the gap **1683** and may be configured so that it can (alternately) contact both the upper portion **1612** of the housing and the connector component **1686**. The details previously provided with respect to the materials and the geometry of the connector component **988** are generally applicable herein.

FIG. **17** shows another example of a partial cross-sectional view of an electronic device. The electronic device **1700** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic devices of any one of FIGS. **4**A through **7**C. The electronic device **1700** includes a housing **1710**, a display assembly **1772** positioned within the housing, and a front cover **1752** positioned over the display assembly **1772**.

The housing **1710** includes a conductive upper portion **1712**, a conductive lower portion **1714**, and a dielectric portion **1734**. The dielectric portion **1734** is positioned within a slot **1730**. The slot **1730** is defined at least in part by a surface **1723** of the upper portion **1712** and by a surface **1725** of the lower portion **1714**. In embodiments, the upper portion **1712** of the housing **1710** defines at least a portion of an antenna element and the slot **1730** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The housing **1710**, the conductive upper portion **1712**, the conductive lower portion **1714**, the dielectric portion **1734**, and the slot **1730** may be formed of similar materials as the housing **110**, the conductive upper portion **112**, the conductive lower portion **114**, the dielectric portion **134**, and the slot **130** and that description is not repeated here.

In the example of FIG. **17**, an electrically insulating element **1707** is disposed over an interior surface region **1727** of the lower portion **1714** of the housing **1710**. The electrically insulating element **1707** also defines a bottom of the gap **1783**. The electrically insulating element **1707** may ensure consistent and reliable operation of the antenna by providing an additional layer of non-conductive material, such as a dielectric material, within a void or gap in the enclosure in which an ingress of fluid may enter and become trapped. The electrically insulating element **1707** may maintain sufficient isolation between conductive and non-conductive components in order to ensure consistent or acceptable operation of the antenna in a similar fashion as previously described with respect to FIG. **16**. The electrically insulating element **1707** may be bonded to the interior surface region **1727** and may be formed of similar materials as previously described with respect to the electrically insulating element **1607** and that description is not repeated here.

In the example of FIG. **17**, the electrically insulating element **1707** protrudes above the level of the region of the surface **1725** that defines the slot **1730**. The electrically insulating element **1707** therefore extends along a portion of an interior surface of the dielectric portion **1734**. In some cases, the electrically insulating element **1707** can thus reduce or prevent a current along an unintended path between the lower portion **1714** of the housing and the upper portion **1712** and/or the connector **1786** and can maintain the performance of the wireless communication system when a conducting fluid is present within the gap **1783**, in a similar fashion as previously discussed with respect to FIG. **16**.

In the example of FIG. **17**, the electrically insulating element **1707** is coupled to a support element **1708**. The electrically insulating element **1707** and the support element **1708** together substantially fill the recess **1781** and, as previously discussed, protrude to some extent from the recess. In the example of FIG. **17**, the electrically insulating element **1707** extends underneath and along a side of the support element **1708**. In some cases, the electrically insulating element may be bonded to the support element **1708**. The support element **1708** is coupled to the display frame **1758** by the coupling element **1709**. The support element **1708** may have a machined or other dimensionally stable surface that is used to mount the coupling element **1709** and ensure a consistent display stack position within the device **1700**.

The electrically insulating element **1707** and the support element **1708** may be formed from different materials. However, each of the electrically insulating element **1707** and the support element **1708** may be formed from an electrically insulating material, particularly in examples where the support element **1708** at least partially defines a bottom of the recess **1783**. The electrically insulating element **1707** may be substantially non-porous, may be configured to inhibit significant diffusion of the fluid and/or its ions through the electrically insulating element, and in some cases may be formed from similar materials as previously described with respect to the electrically insulating element **1607**. In some examples, the electrically insulating element **1707** may be formed from a curable adhesive material, which may be cured in place around the support element **1708**. In a similar fashion as previously discussed with respect to FIG. **16**, the bonding of the electrically insulating element **1707** to the interior surface region **1727** may be enhanced by surface modification of and/or formation of one or more retention features on the interior surface region **1727**. Suitable materials for the support element **1708** include thermoset or thermoplastic polymer materials.

As shown in FIG. **17**, a periphery of the display assembly **1772** is at least partially surrounded by a display frame **1758**. The material(s) of the display frame **1758** may be similar to those previously described for the display frame **1658**. The display frame **1758** may be coupled to the support element **1708** by a coupling element **1709**, which may be an adhesive layer. The front cover **1752** may be coupled to the display frame **1758** with an adhesive. In additional examples, a periphery of the front cover **1752** may be at least partially surrounded by a cover frame, examples of which were previously shown in FIGS. **10**A, **10**B, and **12**. The display assembly **1772** and the front cover **1752** may be similar in function and materials to the display assembly **172** and the front cover **152**.

The electronic device **1700** includes a connector component **1786** that passes through the display frame **1758** and is conductively coupled to the display assembly **1772**. In the example of FIG. **17**, the display assembly **1772** includes an element **1776**, which in some cases may be a display control circuit and the connector component **1786** is conductively coupled to the element **1776**. For example, the connector component **1786** may be conductively coupled to the element **1776** by a conductive adhesive, by solder, or the like. The connector component **1786** may be formed of similar materials as those previously described for the connector components **986** and **988**.

In some embodiments, the electronic device **1700** includes an additional connector component **1788** which may be similar in at least some aspects to the conductor component **988**. The connector component **1788** is shown with dashed lines in FIG. **17** to represent a volume of the gap **1783** which may be occupied by the connector component **1788**. The connector component **1788** does not completely fill the gap **1783** and may be configured so that it can (alternately) contact both the upper portion **1712** of the housing and the connector component **1786**. The details previously provided with respect to the materials and the geometry of the connector component **988** are generally applicable herein.

FIG. **18** shows another example of a partial cross-sectional view of an electronic device. The electronic device **1800** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic devices of any one of FIGS. **4**A through **7**C. The electronic device **1800** includes a housing **1810**, a display assembly **1872** positioned within the housing, and a front cover **1852** positioned over the display assembly **1872**.

The housing **1810** includes a conductive upper portion **1812**, a conductive lower portion **1814**, and a dielectric portion **1834**. The dielectric portion **1834** is positioned within a slot **1830**. The slot **1830** is defined at least in part by a surface **1823** of the upper portion **1812** and by a surface **1825** of the lower portion **1814**. In embodiments, the upper portion **1812** of the housing **1810** defines at least a portion of an antenna element and the slot **1830** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The housing **1810**, the conductive upper portion **1812**, the conductive lower portion **1814**, the dielectric portion **1834**, and the slot **1830** may be formed of similar materials as the housing **110**, the conductive upper portion **112**, the conductive lower portion **114**, the dielectric portion **134**, and the slot **130** and that description is not repeated here.

In the example of FIG. **18**, an electrically insulating element **1807** is interposed between the gap **1883** and an interior surface region **1827** of the lower portion **1814** of the housing. As shown in FIG. **18**, the electrically insulating element **1807** is disposed over some of the interior surface region **1827** but is not disposed over all of the interior surface region **1827**. In other words, the electrically insulating element **1807** only contacts part of the interior surface region **1827**. The electrically insulating element **1807** also defines a bottom of the gap **1883**. The electrically insulating element **1807** may ensure consistent and reliable operation of the antenna by providing an additional layer of non-conductive material, such as a dielectric material, within a void or gap in the enclosure in which an ingress of fluid may enter and become trapped. The electrically insulating element **1807** may maintain sufficient isolation between conductive and non-conductive components in order to ensure consistent or acceptable operation of the antenna in a similar fashion as previously discussed with respect to FIG. **16**.

In the example of FIG. **18**, the electrically insulating element **1807** protrudes above the level of the region of the surface **1825** that defines the slot **1830**. The electrically insulating element **1807** therefore extends along a portion of an interior surface of the dielectric portion **1834**. The electrically insulating element **1807** can thus reduce or prevent a current along an unintended path between the lower portion **1814** of the housing and the upper portion **1812** and/or the connector **1886** and can maintain the performance of the wireless communication system when a conducting fluid is present within the gap **1883**, in a similar fashion as previously discussed with respect to FIGS. **16** and **17**.

In the example of FIG. **18**, the electrically insulating element **1807** is coupled to a support element **1808**. The electrically insulating element **1807** and the support element **1808** together at least partially fill the recess **1881**. In the example of FIG. **18**, the electrically insulating element **1807** protrudes from the recess. The electrically insulating element **1807** and the support element **1808** are coupled to the lower portion **1814** by the coupling element **1809***a*. The support element **1808** is coupled to the display frame **1858** by the coupling element **1809***b*. The support element **1808** may ensure a consistent display stack position within the device **1800** in a similar fashion as previously described with respect to the support element **1708**.

The electrically insulating element **1807** and the support element **1808** may be formed from different materials. However, each of the electrically insulating element **1807** and the support element **1808** may be formed from an electrically insulating material, particularly in examples where the support element **1808** at least partially defines a bottom of the gap **1883**. In some cases, the electrically insulating element **1807** may be deformed to a suitable shape for providing a seal against the ingress of fluid upon coupling of the support element **1808** to the electrically insulating element **1807**. In some cases, the electrically insulating element **1807** is deformed in response to an assembly process in which the display assembly and cover **1852** are inserted into the enclosure or housing assembly. Suitable materials for the electrically insulating element **1807** include elastomeric polymer materials that allow for a predicted amount of deflection while providing a seal to prevent further ingress of trapped liquid. Suitable materials for the electrically insulating element **1807** may also be substantially non-porous and configured to inhibit significant diffusion of the fluid and/or its ions through the electrically insulating element.

The support element **1808** may be formed from a similar material as previously described with respect to the support element **1708**. In the example of FIG. **18**, the support element **1808** is coupled to the lower element **1814** of the housing **1810** by the coupling element **1809***a* and is coupled to the display frame **1858** by the coupling element **1809***b*. The coupling elements **1809***a* and **1809***b* may be similar to the coupling elements **1609** and **1709** and that description is not repeated here.

As shown in FIG. **18**, a periphery of the display assembly **1872** is at least partially surrounded by the display frame **1858**. The material(s) of the display frame **1858** may be similar to those previously described for the display frame **1658**. The front cover **1852** may be coupled to the display frame **1858** with an adhesive. In additional examples, a periphery of the front cover **1852** may be at least partially surrounded by a cover frame, examples of which were previously shown in FIGS. **10**A, **10**B, and **12**. The display assembly **1872** and the front cover **1852** may be similar in function and materials to the display assembly **172** and the front cover **152**.

The electronic device **1800** includes a connector component **1886** that passes through the display frame **1858** and is conductively coupled to the display assembly. In the example of FIG. **18**, the display assembly **1872** includes an element **1876**, which in some cases may be a display control circuit and the connector component **1886** is conductively coupled to the element **1876**. For example, the connector component **1886** may be conductively coupled to the element **1876** as previously discussed with respect to FIG. **17**. The connector component **1886** may be formed of similar materials as those previously described for the connector components **986** and **988**.

In some embodiments, the electronic device **1800** includes an additional connector component **1888** which may be similar in at least some aspects to the conductor component **988**. The connector component **1888** is shown with dashed lines in FIG. **18** to represent a volume of the gap **1883** which may be occupied by the connector component **1888**. The connector component **1888** does not completely fill the gap **1883** and may be configured so that it can (alternately) contact both the upper portion **1812** of the housing and the connector component **1886**. The details previously provided with respect to the materials and the geometry of the connector component **988** are generally applicable herein.

FIG. **19** shows another example of a partial cross-sectional view of an electronic device. The electronic device **1900** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic devices of any one of FIGS. **4**A through **7**C. The electronic device **1900** includes a housing **1910**, a display assembly **1972** positioned within the housing, and a front cover **1952** positioned over the display assembly **1972**.

The housing **1910** includes a conductive upper portion **1912**, a conductive lower portion **1914**, and a dielectric portion **1934**. The dielectric portion **1934** is positioned within a slot **1930**. The slot **1930** is defined at least in part by a surface **1923** of the upper portion **1912** and by a surface **1925** of the lower portion **1914**. In embodiments, the upper portion **1912** of the housing **1910** defines at least a portion of an antenna element and the slot **1930** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The housing **1910**, the conductive upper portion **1912**, the conductive lower portion **1914**, the dielectric portion **1934**, and the slot **1930** may be formed of similar materials as the housing **110**, the conductive upper portion **112**, the conductive lower portion **114**, the dielectric portion **134**, and the slot **130** and that description is not repeated here.

In the example of FIG. **19**, an electrically insulating element **1907** is used to form a mechanical seal. The electrically insulating element **1907** may ensure consistent and reliable operation of the antenna by preventing ingress of fluid into at least part of a void or gap of the enclosure. The electrically insulating element **1907** may thus maintain sufficient isolation between conductive and non-conductive components in order to ensure consistent or acceptable operation of the antenna. In some cases, the electrically insulating element **1907** reduces or prevents a current along an unintended path between the lower portion **1914** of the housing and the upper portion **1912** and/or the connector **1986**. The electrically insulating element **1907** may be in the form of a gasket, such as an O-ring. The gap **1983** includes a groove portion **1980** and the electrically insulating element **1907** is positioned with the groove portion **1980**. In the example of FIG. **19**, the groove portion **1980** is defined by the lower portion **1914** of the housing, the dielectric portion **1934**, and the dielectric frame **1958**, but in additional examples the groove portion may be defined by different components of the electronic device. The electrically insulating element **1907** has a generally circular cross-section, but this example is not limiting and, in other examples, the electrically insulating element may have a square or rectangular cross-section. In some cases, the electrically insulating element **1907** is formed from an elastomeric polymer material, such as an acrylonitrile butadiene rubber, a chloroprene rubber, an ethylene-propylene diene rubber, or the like. The electrically insulating element **1907** may have similar properties to the materials previously described with respect to the electrically insulating element **1807**.

As shown in FIG. **19**, a periphery of the display assembly **1972** is at least partially surrounded by a display frame **1958**. The material(s) of the display frame **1958** may be similar to those previously described for the display frame **1658**. The front cover **1952** may be coupled to the display frame **1958** with an adhesive. In additional examples, a periphery of the front cover **1952** may be at least partially surrounded by a cover frame, examples of which were previously shown in FIGS. **10**A, **10**B, and **12**. The display frame **1958** is coupled to the lower portion **1914** of the housing by the coupling element **1909**. The coupling element **1909** may be similar to the coupling elements **1609** and **1709**. The front cover **1952** may be coupled to the display frame **1958** with an adhesive. The display assembly **1972** and the front cover **1952** may be similar in function and materials to the display assembly **172** and the front cover **152**.

The electronic device **1900** includes a connector component **1986** that passes through the display frame **1958** and is conductively coupled to display assembly. In the example of FIG. **19**, the display assembly **1972** includes an element **1976**, which in some cases may be a display control circuit and the connector component **1986** is conductively coupled to the element **1976**. For example, the connector component **1986** may be conductively coupled to the element **1976** as previously discussed with respect to FIG. **17**. The connector component **1986** may be formed of similar materials as those previously described for the connector components **986** and **988**.

In some embodiments, the electronic device **1900** includes an additional connector component **1988** which may be similar in at least some aspects to the conductor component **988**. The connector component **1988** is shown with dashed lines in FIG. **19** to represent a volume of the gap **1983** which may be occupied by the connector component **1988**. The connector component **1988** does not completely fill the gap **1983** and may be configured so that it can (alternately) contact both the upper portion **1912** of the housing and the connector component **1986**. The details previously provided with respect to the materials and the geometry of the connector component **988** are generally applicable herein.

FIG. **20** shows another example of a partial cross-sectional view of an electronic device. The electronic device **2000** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic devices of any one of FIGS. **4**A through **7**C. The electronic device **2000** includes a housing **2010**, a display assembly **2072** positioned within the housing, and a front cover **2052** positioned over the display assembly **2072**.

The housing **2010** includes a conductive upper portion **2012**, a conductive lower portion **2014**, and a dielectric portion **2034**. The dielectric portion **2034** is positioned within a slot **2030**. The slot **2030** is defined at least in part by a surface **2023** of the upper portion **2012** and by a surface **2025** of the lower portion **2014**. In embodiments, the upper portion **2012** of the housing **2010** defines at least a portion of an antenna element and the slot **2030** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The housing **2010**, the conductive upper portion **2012**, the conductive lower portion **2014**, the dielectric portion **2034**, and the slot **2030** may be formed of similar materials as the housing **110**, the conductive upper portion **112**, the conductive lower portion **114**, the dielectric portion **134**, and the slot **130** and that description is not repeated here.

In the example of FIG. **20**, an electrically insulating element **2007** is interposed between the gap **2083** and an interior surface region **2027** of the lower portion **2014** of the housing. As shown in FIG. **20**, the electrically insulating element **2007** is disposed over some of the interior surface region **2027** but is not disposed over all of the interior surface region **2027**. In other words, the electrically insulating element **2007** only contacts part of the interior surface region **2027**. In other examples, the electrically insulating element **2007** may completely cover (e.g., contact) an entirety of the interior surface region **2027** or may be positioned higher up in the device so that the electrically insulating element does not contact any of the interior surface region **2027**. The electrically insulating element **2007** may ensure consistent and reliable operation of the antenna by providing an additional layer of non-conductive material, such as a dielectric material, within a void or gap in the enclosure in which an ingress of fluid may enter and become trapped. The electrically insulating element **2007** may maintain sufficient isolation between conductive and non-conductive components in order to ensure consistent or acceptable operation of the antenna in a similar fashion as previously discussed with respect to FIG. **16**.

The electrically insulating element **2007** may be bonded to one or more portions of the housing and to one or more internal components of the device that define the gap **2083**. In the example of FIG. **20**, the electrically insulating element **2007** may be bonded to the lower portion **2014** of the housing, the dielectric portion **2034**, and the display frame **2058**. The electrically insulating element **2007** may be chemically bonded, mechanically bonded, or both to one or more elements of the electronic device. In some cases, the electrically insulating element **2007** may be formed from a curable adhesive material, such as a thermosetting resin adhesive (e.g., an epoxy-based resin). The curable adhesive material may be introduced into the gap **2083** between the front cover **2052** and the upper portion **2012** of the housing and then cured at a desired location.

As shown in FIG. **20**, a periphery of the display assembly **2072** is at least partially surrounded by a display frame **2058**. The material(s) of the display frame **2058** may be similar to those previously described for the display frame **1658**. The display frame **2058** may be coupled to the lower portion **2014** of the housing by a coupling element **2009**, which may be an adhesive layer. The coupling element **2009** may be similar to the coupling elements **1609** and **1709**. The front cover **2052** may be coupled to the display frame **1658** with an adhesive. In additional examples, a periphery of the front cover **2052** may be at least partially surrounded by a cover frame, examples of which were previously shown in FIGS. **10**A, **10**B, and **12**. The display assembly **2072** and the front cover **2052** may be similar in function and materials to the display assembly **172** and the front cover **152**.

The electronic device **2000** includes a connector component **2086** that passes through the display frame **2058** and is conductively coupled to the display assembly **2072**. For example, the connector component **2086** may be conductively coupled to the display assembly **2072** as previously discussed with respect to FIG. **17**. In the example of FIG. **20**, the display assembly **2072** includes an element **2076**, which in some cases may be a display control circuit and the connector component **2086** is conductively coupled to the element **2076**. For example, the connector component **2086** may be conductively coupled to the element **2076** as previously discussed with respect to FIG. **17**. The connector component **2086** may be formed of similar materials as those previously described for the connector components **986** and **988**.

In some embodiments, the electronic device **2000** includes an additional connector component **2088** which may be similar in at least some aspects to the conductor component **988**. The connector component **2088** is shown with dashed lines in FIG. **20** to represent a volume of the gap **2083** which may be occupied by the connector component **2088**. The connector component **2088** does not completely fill the gap **2083** and may be configured so that it can (alternately) contact both the upper portion **2012** of the housing and the connector component **2086**. The details previously provided with respect to the materials and the geometry of the connector component **988** are generally applicable herein.

FIG. **21** shows another example of a partial cross-sectional view of an electronic device. The electronic device **2100** may be an example cross-section of the electronic device **100** of FIG. **1** or the electronic devices of any one of FIGS. **4**A through **7**C. The electronic device **2100** includes a housing **2110**, a display assembly **2172** positioned within the housing, and a front cover **2152** positioned over the display assembly **2172**.

The housing **2110** includes a conductive upper portion **2112**, a conductive lower portion **2114**, and a dielectric portion **2134**. The dielectric portion **2134** is positioned within a slot **2130**. The slot **2130** is defined at least in part by a surface **2123** of the upper portion **2112** and by a surface **2125** of the lower portion **2114**. In embodiments, the upper portion **2112** of the housing **2110** defines at least a portion of an antenna element and the slot **2130** is configured to radiate at one or more desired frequencies, as previously discussed with respect to FIG. **1**. The housing **2110**, the conductive upper portion **2112**, the conductive lower portion **2114**, the dielectric portion **2134**, and the slot **2130** may be formed of similar materials as the housing **110**, the conductive upper portion **112**, the conductive lower portion **114**, the dielectric portion **134**, and the slot **130** and that description is not repeated here.

In the example of FIG. **21**, the upper portion **2112** of the housing defines a protruding portion **2113** that is conductively coupled to the display assembly. For example, the protruding portion **2113** may be conductively coupled to the display assembly **2172** by a conductive adhesive, by solder, or the like. The protruding portion extends from an interior surface **2124** of the upper portion and extends below the display frame **2158**. The protruding portion may be coupled to the display frame **2158**. The protruding portion **2113** also extends over the dielectric portion **2134** and may be coupled to the dielectric portion. In the example of FIG. **21**, the protruding portion **2113** also extends over a support element **2159**. The support element **2159** may be coupled to the protruding portion and also to the dielectric portion **2134**. The support element **2159** may be formed of an electrically insulating material, such as the materials previously described with respect to the support elements **1708** and **1808**.

The electronic device **2100** is configured to prevent ingress of fluid through each of two gaps, **2183***a* and **2183***b*. The upper portion **2112** of the housing **2110** and the cover frame **2156** partially define the gap **2183***a*. The display frame **2158** defines a bottom of the gap **2183***a*. The cover frame **2156** and the display frame **2158** may be configured to prevent ingress of a liquid that may be present within the gap **2183***a* towards the lower portion **2114** of the electronic device. The conductive lower portion **2114** and the dielectric portion **2134** of the housing define the gap **2183***b*. An electrically insulating element **2107** is positioned between the surface **2143** of the dielectric portion **2134** and the surface **2143** of the conductive lower portion **2114**. The electrically insulating element **2107** may be configured to prevent ingress of a liquid that may be present in the gap **2183***b* towards the interior surface region **2127** of the conductive lower portion **2114**. Suitable materials for the electrically insulating element **2107** include, but are not limited to, curable adhesive materials, such as a thermosetting resin adhesive (e.g., an epoxy-based resin adhesive). In some cases, the bonding of the electrically insulating element **2107** to one or more of the surfaces may be enhanced by surface modification of one or more of the surface **2143** or the surface **2125**. Configuration of the electronic device **2100** to limit ingress of a conductive fluid into an interior region of the device may help maintain the performance of the wireless communication in a similar fashion as previously described with respect to at least FIGS. **16** and **19**.

The display assembly **2172** includes an element **2186**, which may be a display control circuit, and the protruding portion **2113** may be conductively coupled to the display control circuit as previously discussed with respect to FIG. **17**. As shown in FIG. **21**, a periphery of the display assembly **2172** is at least partially surrounded by a display frame **2158**. The material(s) of the display frame **2158** may be similar to those previously described for the display frame **1658**. A periphery of the front cover **2152** is at least partially surrounded by a cover frame **2156**. In some cases, the cover frame is coupled to the display frame **2158**, such as with an adhesive. The display assembly **2172** and the front cover **2152** may be similar in function and materials to the display assembly **172** and the front cover **152**.

FIG. **22** shows a block diagram of a sample electronic device that can incorporate a housing as described herein. The schematic representation depicted in FIG. **22** may correspond to components of the devices depicted in FIGS. **1** to **21** as described above. However, FIG. **22** may also more generally represent other types of electronic devices including a housing as described herein.

In embodiments, an electronic device **2200** may include sensors **2212** to provide information regarding configuration and/or orientation of the electronic device in order to control the output of the display. For example, a portion of the display **2220** may be turned off, disabled, or put in a low energy state when all or part of the viewable area of the display **2220** is blocked or substantially obscured. As another example, the display **2220** may be adapted to rotate the display of graphical output based on changes in orientation of the device **2200** (e.g., 90 degrees or 180 degrees) in response to the device **2200** being rotated.

The electronic device **2200** also includes a processing unit **2202** operably connected with a computer-readable memory **2206**. The processing unit **2202** may be operatively connected to the memory **2206** component via an electronic bus or bridge. The processing unit **2202** may be implemented as one or more computer processors or microcontrollers configured to perform operations in response to computer-readable instructions. The processing unit **2202** may include a central processing unit (CPU) of the device **2200**. Additionally, and/or alternatively, the processing unit **2202** may include other electronic circuitry within the device **2200** including application specific integrated chips (ASIC) and other microcontroller devices. The processing unit **2202** may be configured to perform functionality described in the examples above.

The memory **2206** may include a variety of types of non-transitory computer-readable storage media, including, for example, read access memory (RAM), read-only memory (ROM), erasable programmable memory (e.g., EPROM and EEPROM), or flash memory. The memory **2206** is configured to store computer-readable instructions, sensor values, and other persistent software elements.

The electronic device **2200** may include control circuitry **2210**. The control circuitry **2210** may be implemented in a single control unit and not necessarily as distinct electrical circuit elements. As used herein, "control unit" will be used synonymously with "control circuitry." The control circuitry **2210** may receive signals from the processing unit **2202** or from other elements of the electronic device **2200**.

As shown in FIG. **22**, the electronic device **2200** includes a battery **2214** that is configured to provide electrical power to the components of the electronic device **2200**. The battery **2214** may include one or more power storage cells that are linked together to provide an internal supply of electrical power. The battery **2214** may be operatively coupled to power management circuitry that is configured to provide appropriate voltage and power levels for individual components or groups of components within the electronic device **2200**. The battery **2214**, via power management circuitry, may be configured to receive power from an external source, such as an alternating current power outlet. The battery **2214** may store received power so that the electronic device **2200** may operate without connection to an external power source for an extended period of time, which may range from several hours to several days.

In some embodiments, the electronic device **2200** includes one or more input devices **2216**. The input device **2216** is a device that is configured to receive input from a user or the environment. The input device **2216** may include, for example, a push button, a touch-activated button, a capacitive touch sensor, a touch screen (e.g., a touch-sensitive display or a force-sensitive display), a capacitive touch button, dial, crown, or the like. In some embodiments, the input device **2216** may provide a dedicated or primary function, including, for example, a power button, volume buttons, home buttons, scroll wheels, and camera buttons.

The device **2200** may also include one or more sensors or sensor modules, such as a touch sensor **2204**, a force sensor **2208**, or other sensors **2212** such as a capacitive sensor, an accelerometer, a barometer, a gyroscope, a proximity sensor, a light sensor, or the like. In some cases, the device **2200** includes a sensor array (also referred to as a sensing array) which includes multiple sensors. For example, a sensor array associated with a protruding feature of a cover member may include an ambient light sensor, a Lidar sensor, and a microphone. The sensors may be operably coupled to processing circuitry. In some embodiments, the sensors may detect deformation and/or changes in configuration of the electronic device and be operably coupled to processing circuitry that controls the display based on the sensor signals. In some implementations, output from the sensors is used to reconfigure the display output to correspond to an orientation or folded/unfolded configuration or state of the device. Example sensors for this purpose include accelerometers, gyroscopes, magnetometers, and other similar types of position/orientation sensing devices. In addition, the sensors may include a microphone, acoustic sensor, light sensor (including ambient light, infrared (IR) light, ultraviolet (UV) light, optical facial recognition sensor, a depth measuring sensor (e.g., a time-of-flight sensor), a health monitoring sensor (e.g., an electrocardiogram (erg) sensor, a heart rate sensor, a photoplethysmogram (ppg) sensor, a pulse oximeter, a biometric sensor (e.g., a fingerprint sensor), or other types of sensing device.

In some embodiments, the electronic device **2200** includes one or more output devices configured to provide output to a user. The output device may include a display **2220** that renders visual information generated by the processing unit **2202**. The output device may also include one or more speakers to provide audio output. The output device may also include one or more haptic devices that are configured to produce a haptic or tactile output along an exterior surface of the device **2200**.

The display **2220** may include a liquid-crystal display (LCD), a light-emitting diode (LED) display, an LED-backlit LCD display, an organic light-emitting diode (OLED) display, an active layer organic light-emitting diode (AMOLED) display, an organic electroluminescent (EL) display, an electrophoretic ink display, or the like. If the display **2220** is a liquid-crystal display or an electrophoretic ink display, the display **2220** may also include a backlight component that can be controlled to provide variable levels of display brightness. If the display **2220** is an organic light-emitting diode or an organic electroluminescent-type display, the brightness of the display **2220** may be controlled by modifying the electrical signals that are provided to display elements. In addition, information regarding configuration and/or orientation of the electronic device may be used to control the output of the display as described with respect to the sensors **2212**. In some cases, the display is integrated with a touch and/or force sensor in order to detect touches and/or forces applied along an exterior surface of the device **2200**.

The electronic device **2200** may also include a communication port **2218** that is configured to transmit and/or receive signals or electrical communication from an external or separate device. The communication port **2218** may be configured to couple to an external device via a cable, adaptor, or other type of electrical connector. In some embodiments, the communication port **2218** may be used to couple the electronic device **2200** to a host computer.

The electronic device **2200** may also include at least one accessory, such as a camera, a flash for the camera, or other such device. The camera may be part of a camera array or sensing array that may be connected to other parts of the electronic device **2200** such as the control circuitry **2210**.

As used herein, the terms "about," "approximately," "substantially," "similar," and the like are used to account for relatively small variations, such as a variation of +/−10%, +/−5%, +/−2%, or +/−1%. In addition, use of the term "about" in reference to the endpoint of a range may signify a variation of +/−10%, +/−5%, +/−2%, or +/−1% of the endpoint value. In addition, disclosure of a range in which at least one endpoint is described as being "about" a specified value includes disclosure of the range in which the endpoint is equal to the specified value.

As used herein, the phrase "one or more of" or "at least one of" or "preceding a series of items, with the term "and" or "or" to separate any of the items, modifies the list as a whole, rather than each member of the list. The phrase "one or more of" or "at least one of" does not require selection of at least one of each item listed; rather, the phrase allows a meaning that includes at a minimum one of any of the items, and/or at a minimum one of any combination of the items, and/or at a minimum one of each of the items. By way of example, the phrases "one or more of A, B, and C" or "one or more of A, B, or C" each refer to only A, only B, or only C; any combination of A, B, and C; and/or one or more of each of A, B, and C. Similarly, it may be appreciated that an order of elements presented for a conjunctive or disjunctive list provided herein should not be construed as limiting the disclosure to only that order provided.

The following discussion applies to the electronic devices described herein to the extent that these devices may be used to obtain personally identifiable information data. It is well understood that the use of personally identifiable information should follow privacy policies and practices that are generally recognized as meeting or exceeding industry or governmental requirements for maintaining the privacy of users. In particular, personally identifiable information data should be managed and handled so as to minimize risks of unintentional or unauthorized access or use, and the nature of authorized use should be clearly indicated to users.

The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the described embodiments. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the described embodiments. Thus, the foregoing descriptions of the specific embodiments described herein are presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the embodiments to the precise forms disclosed. It will be apparent to one of ordinary skill in the art that many modifications and variations are possible in view of the above teachings.

What is claimed is:

1. An electronic device comprising:
- a display assembly comprising a first antenna element of a wireless communication system;
- a cover positioned over the display assembly; and
- a housing defining:
  - an upper conductive portion at least partly surrounding the cover and defining a first portion of the exterior of the housing, the upper conductive portion defining a second antenna element of the wireless communication system, the second antenna element operably coupled to the first antenna element;
  - a lower conductive portion defining a second portion of the exterior of the housing;
  - a conductive bridge portion electrically connecting the upper conductive portion and the lower conductive portion of the housing and defining a third portion of the exterior of the housing;
  - a slot defined between the upper conductive portion and the lower conductive portion of the housing; and
  - a dielectric portion positioned at least partly within the slot.

2. The electronic device of claim **1**, wherein the wireless communication system is configured to resonate each of the first antenna element and the second antenna element.

3. The electronic device of claim **1**, wherein the first antenna element is conductively coupled to the second antenna element.

4. The electronic device of claim **3**, wherein the first antenna element is conductively coupled to the upper conductive portion of the housing at a plurality of discrete locations.

5. The electronic device of claim **1**, wherein the lower conductive portion of the housing is conductively coupled to an electrical ground.

6. The electronic device of claim **1**, wherein:
- the exterior of the housing includes four side surfaces;
- each of the four side surfaces defines a region of the slot; and
- the conductive bridge portion is located on one of the four side surfaces.

7. The electronic device of claim **1**, wherein:
- the electronic device is a wearable device;
- the slot has a length ranging from 17 mm to 150 mm; and
- the slot is configured to radiate in a frequency range from 1 GHz to 9 GHz.

8. An electronic device comprising:
- a display assembly comprising a display component and a first antenna element;
- a front cover positioned over the display assembly;
- a housing comprising:
  - a housing member formed from a conductive material, the housing member defining:
    - a first portion at least partly surrounding the front cover and defining:
      - an upper portion of a side surface of the housing; and
      - a second antenna element operably coupled to the first antenna element; and
    - a second portion defining a lower portion of the side surface of the housing;
    - a third portion extending from the first portion to the second portion and defining an intermediate portion of the side surface of the housing; and
  - a dielectric member positioned at least partially within a slot defined at least in part by the first, the second, and the third portions of the housing member; and
- a wireless communication circuit operably coupled to the first antenna element and the second antenna element and configured to transmit wireless signals along a region of the housing including the slot.

9. The electronic device of claim **8**, wherein:
- the first antenna element is defined by a conductive layer of the display component and is configured to resonate at a first frequency; and
- the conductive layer is conductively coupled to the first portion of the housing member.

10. The electronic device of claim **9**, wherein:
- the second portion of the housing member is coupled to an electrical ground; and
- the electronic device further comprises a switchable ground conductively coupled to the first portion of the housing member.

11. The electronic device of claim **8**, wherein at least one of the first portion or the second portion of the housing member defines a retention feature that interlocks with the dielectric member.

12. The electronic device of claim **8**, wherein:
- the slot is a first slot, and the dielectric member is a first dielectric member;
- the housing member further defines a second slot positioned between the first portion and the second portion of the housing member; and
- the housing further comprises a second dielectric member positioned within the second slot.

13. The electronic device of claim **8**, wherein:
- the electronic device is a watch; and
- the watch comprises:
  - a sensing panel; and
  - a rear cover positioned over the sensing panel and coupled to the lower portion of the housing member.

14. The electronic device of claim **13**, wherein:
- the first, the second, and the third portions of the housing member are formed from a titanium-based alloy; and
- the dielectric member is formed from a polymer material molded into the slot defined between the first and the second portions of the housing.

15. An electronic device comprising:
- a display assembly comprising a circuit assembly comprising a first antenna element of a wireless communication system;
- a housing defining:
  - a first conductive portion defining a first portion of an exterior surface of the housing and a second antenna element of the wireless communication system, the second antenna element conductively coupled to the first antenna element;
  - a second conductive portion defining a second portion of the exterior surface;
  - a third conductive portion connecting the first and the second conductive portions and defining a third portion of the exterior surface, the first, the second,

and the third conductive portions of the housing at least partially defining a slot; and

a dielectric portion positioned at least partially within the slot and defining a fourth portion of the exterior surface; and

a cover positioned over the display assembly.

16. The electronic device of claim **15**, wherein:

the slot is configured to operate as a radiating element of the wireless communication system; and

the second conductive portion is conductively coupled to an electrical ground.

17. The electronic device of claim **16**, wherein the housing defines four sides and the slot extends across three of the four sides.

18. The electronic device of claim **16**, wherein an edge of the first conductive portion is separated from an edge of the second conductive portion by an average distance ranging from 1 mm to 2 mm.

19. The electronic device of claim **16**, wherein the dielectric portion of the housing is formed from a material having a dielectric constant ranging from 2 to 4.

20. The electronic device of claim **15**, further comprising a display frame at least partially surrounding the display assembly, wherein:

an outer surface of the display frame and an interior surface of at least one of the first conductive portion or the dielectric portion at least partially defines a gap;

at least one connector component extends into the gap and operatively couples the first antenna element to the second antenna element; and

the electronic device further comprises an electrically insulating element interposed between the at least one connector component and an interior surface of the second conductive portion.

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