

FIG. 1

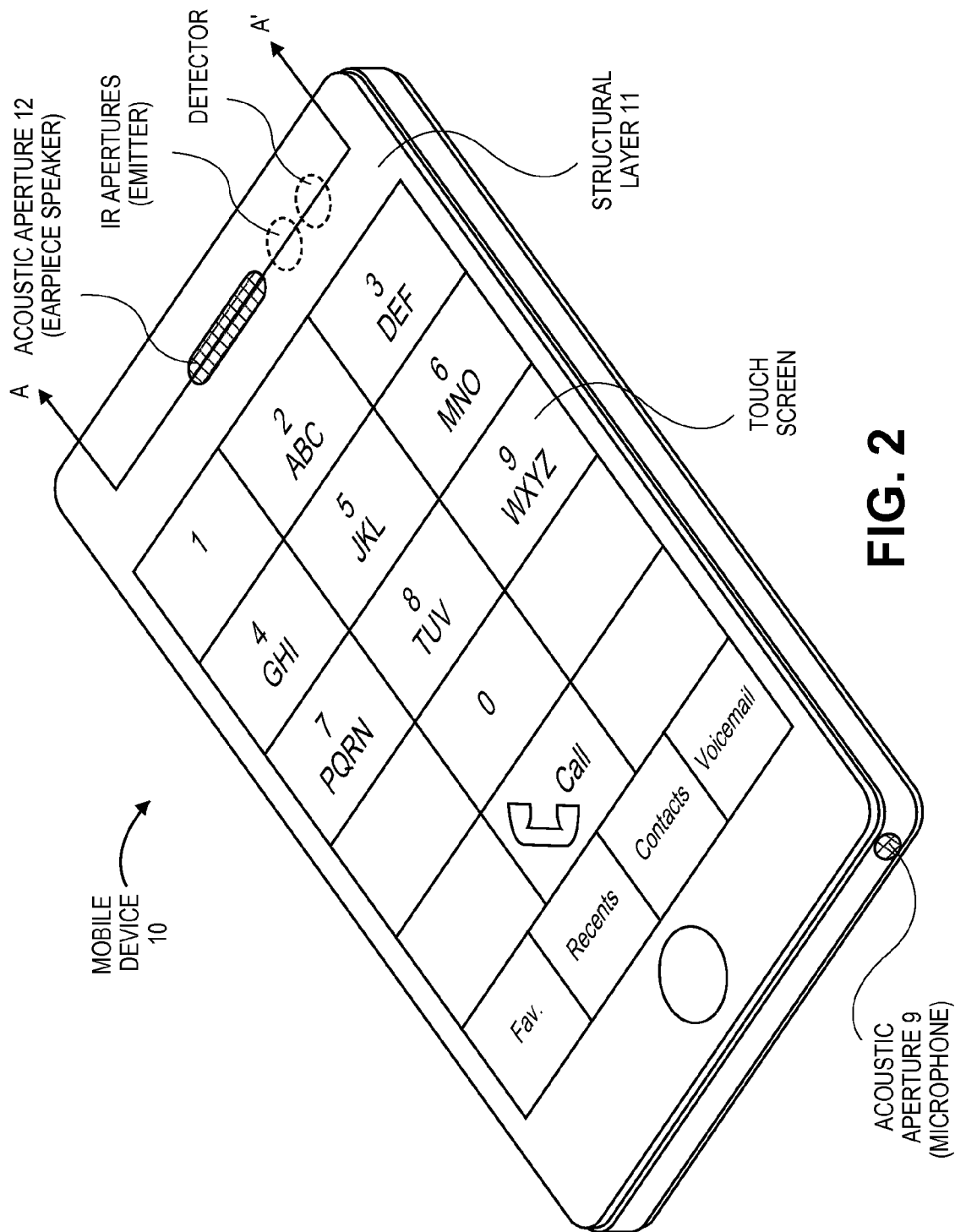
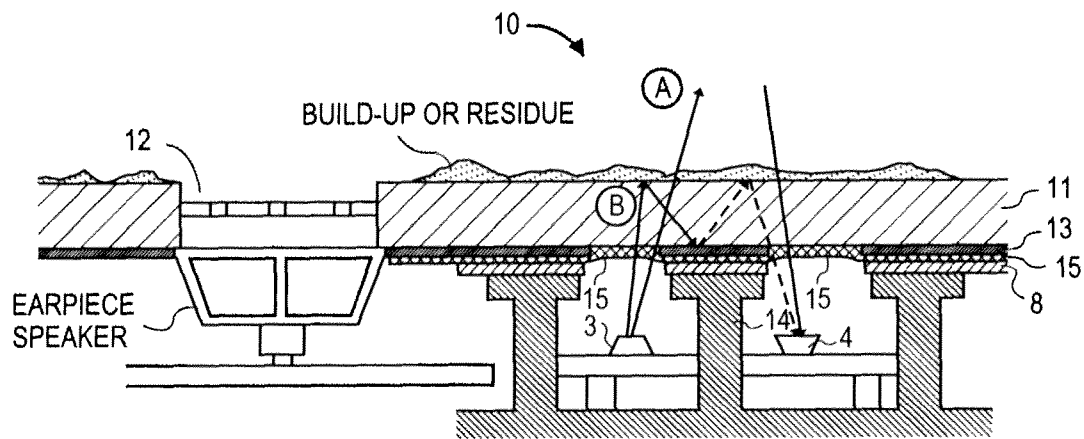
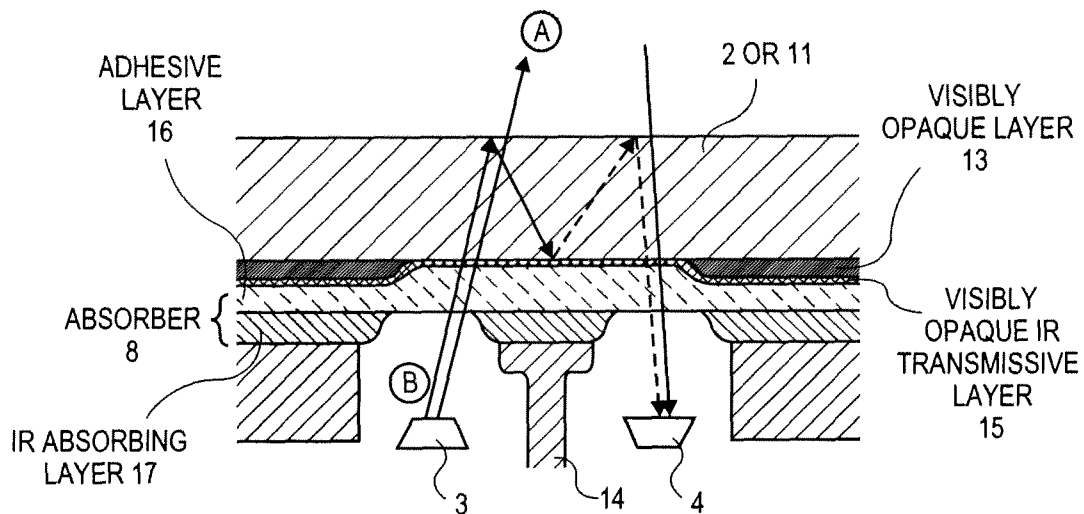


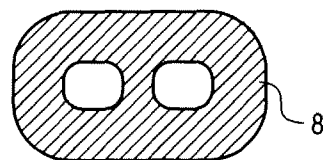
FIG. 2



**FIG. 3**



**FIG. 4**



**FIG. 5**

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## PROXIMITY SENSOR ARRANGEMENT IN A MOBILE DEVICE

### FIELD

An embodiment of the invention is directed to a proximity sensor arrangement used in a handheld mobile communications device. Other embodiments are also described.

### BACKGROUND

In the field of personal mobile devices such as laptop computers, tablet computers, and smart phones, proximity sensors are used to sense hover events. These are no touch, close proximity positioning of parts of the user's body or other objects (e.g., a stylus held by the user), near an external surface of the device. Typically, such proximity sensors are designed to detect an external object that is located outside the near field detection capability of a touch sensor (e.g., those used in a typical touch screen display such as found in an iPhone™ device by Apple Inc.). In one instance, the proximity sensor includes an infrared emitter and a counterpart infrared detector that are controlled and sampled by proximity sensor circuitry integrated in the housing of the mobile device. Emitted infrared radiation is scattered by the external object, and then detected and analyzed to infer that an external object is (or is not) close to the exterior surface. In the case of handheld mobile communications devices, the sensor may be located near an acoustic aperture for an earpiece speaker (receiver) of a mobile communications handset, and is used to determine when the handset is being held close to the user's ear, as opposed to away from the ear. When the proximity sensor indicates that the external object, in this case, the user's ear or head, is sufficiently close, then a predetermined action is taken, including, for example, turning off or disabling a touch screen display that is on the same external face of the housing as the acoustic aperture. This, of course, is designed to avoid unintended touch events caused by the user's cheek, while the handset is held close to the user's ear during a call.

### SUMMARY

An electronic device having a proximity sensor assembly includes a radiation passing layer having a top surface and a bottom surface. A proximity sensor having an emitter and a detector is positioned below the radiation passing layer. A radiation shield positioned between the emitter and the detector extends to the bottom surface of the radiation passing layer. A radiation absorber, which is a separate piece and of a separate material than the shield, is positioned to provide a radiation seal between a top surface of the shield and the bottom surface of the radiation passing layer. By virtue of its radiation absorption characteristics, together with its positioning and contact with the bottom of the radiation passing layer, the absorber may help prevent stray radiation from the emitter that may have been internally reflected within the radiation passing layer, from impinging on the detector. This internally reflected stray radiation (which is attenuated by the absorber) may be caused by original radiation from the emitter that has been internally reflected from oily build-up and residue, also referred to here as smudge, that has formed on the exterior surface of the radiation passing layer due to normal use of the device. As a result, a more accurate proximity sensor may be obtained.

The above summary does not include an exhaustive list of all aspects of the present invention. It is contemplated that the

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invention includes all systems and methods that can be practiced from all suitable combinations of the various aspects summarized above, as well as those disclosed in the Detailed Description below and particularly pointed out in the claims filed with the application. Such combinations have particular advantages not specifically recited in the above summary.

### BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments of the invention are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" or "one" embodiment of the invention in this disclosure are not necessarily to the same embodiment, and they mean at least one.

FIG. 1 illustrates relevant portions of an electronic device, in accordance with an embodiment of the invention.

FIG. 2 depicts an example mobile device in which an embodiment of the invention can be implemented.

FIG. 3 is a sectional view along the line A, A' of FIG. 2.

FIG. 4 is a sectional view of the proximity sensor arrangement, according to another embodiment of the invention.

FIG. 5 is a top view of an example radiation absorber.

### DETAILED DESCRIPTION

Several embodiments of the invention with reference to the appended drawings are now explained. Whenever the shapes, relative positions and other aspects of the parts described in the embodiments are not clearly defined, the scope of the invention is not limited only to the parts shown, which are meant merely for the purpose of illustration. Also, while numerous details are set forth, it is understood that some embodiments of the invention may be practiced without these details. In other instances, well-known circuits, structures, and techniques have not been shown in detail so as not to obscure the understanding of this description.

FIG. 1 illustrates relevant portions of an electronic device, in accordance with an embodiment of the invention. A sectional view of the device and, in particular, a region near its exterior surface is shown that contains a radiation passage for a proximity sensor in the device. A radiation passing layer 2 separates an interior region of the device from the outside where an external object is located nearby. The radiation passing layer may be a cover or a cap which, as described further below, may also be a structural layer (e.g., part of a front facing structural plate) of the device. It may be flat as shown or somewhat curved, e.g. to provide a lens effect to the passing radiation. It may be made of a single material such as glass, ceramic, polycarbonate, or acrylic, or it may be a composite or laminate of several layers of different materials. It may function as a protective barrier, and/or it may have an aesthetic function to provide a certain look from the outside. In any case, the radiation passing layer 2 is sufficiently transmissive in a radiation band of interest, and in particular in this embodiment the infrared (IR) band, in order to permit an IR proximity sensor that is located below it to function as intended. An instance of the radiation passing layer 2 is the structural layer 11 described below in connection with FIG. 3.

The proximity sensor includes an emitter 3, which emits the radiation (here, IR) and a counterpart detector 4, which is designed to detect impinging radiation. The emitter 3 and the detector 4 have their sensitive surfaces aimed at the radiation passing layer 2, either directly or indirectly (e.g., through a prism or mirror arrangement). Both are controlled and/or sensed electrically by proximity sensor circuitry 5. This com-

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combination of the emitter, detector and proximity sensor circuitry may be a conventional, microelectronic infrared proximity sensor unit, e.g. an IR light emitting diode (LED)-based unit with a built-in light collector (lens), analog to digital conversion circuitry, and a digital communication interface to a processor (not shown). The detector may be part of a shared microelectronic device that can also be used to detect in other radiation bands, e.g. visible light. The data processor may be running proximity software that analyzes readings or samples from the proximity sensor circuitry 5, based on what has been emitted and what has been detected (as scattered or reflected radiation from the external object). The proximity software may then make a determination as to whether the external object is close, far, or in between.

Between the emitter 3 and the detector 4 is a radiation shield 7 that extends upwards to the bottom surface of the radiation passing layer 2, as shown. The shield in this case has a simple solid or polyhedron shape, but alternatively may have a more complex shape such as a T-shape. At its bottom, the radiation shield 7 may be secured to a frame (not shown) or a printed circuit board (not shown) on which the emitter 3 and the detector 4 are also installed.

The shield 7 serves to block stray radiation originating from the emitter 3, i.e. by at least reflecting stray radiation but may also absorb some of it to a limited extent. The shield's top surface could be affixed to the bottom surface of the radiation passing layer, e.g. by virtue of being glued or bonded to the bottom of an absorber 8; alternatively, its top surface could simply rest against the absorber 8, and be affixed at its bottom to a printed circuit board or other substrate or platform on which the proximity sensor is installed. The shield 7 could be a structural wall that can bear a vertical load; alternatively it could just be a fence. An instance of the shield 7 is the frame member 14 described below in connection with FIG. 3.

As seen in FIG. 1, the top surface of the shield 7 conforms to the bottom surface of the radiation passing layer 2, by virtue of being in contact with and conforming to an absorber 8. The radiation absorber 8 may be a separate piece and of a different material than the shield 7, and is positioned to provide a radiation seal between a top surface of the shield 7 and the bottom surface of the radiation passing layer 2. A gap-free joiner of the three components (the shield 7, the absorber 8, and the radiation passing layer 2) is desired in order to provide a proper radiation seal along the shield, in a horizontal or "Z" direction that is perpendicular to the plane of the sectional view shown in FIG. 1. This may be achieved by having the surfaces of those components conform to each other as shown. In addition, the absorber 8 may be bonded to the bottom of the radiation passing layer 2 via an adhesive layer (not shown in FIG. 1) that contains an index-matching material which reduces the difference in refraction index (for the radiation band used by the proximity sensor) between the absorber 8 and the radiation passing layer 2.

The absorber 8 covers the adjoining surfaces of the radiation passing layer 2 and the shield 7 but leaves open and separates two areas directly above the emitter 3 and the detector 4, respectively. This permits transmitted radiation and reflected/scattered radiation to pass, in this case in a substantially vertical direction, through the radiation passing layer 2 as shown, enabling the proximity sensor to work. The absorber 8 could be an otherwise continuous layer having two holes formed therein as shown in the top view of FIG. 5. The absorber 8 has a thickness in the vertical direction, and a width and length in the horizontal directions so as to sufficiently absorb stray radiation that has been internally reflected in the radiation passing layer 2 (which is depicted as a dotted line labeled "B" in the figures). The internal reflec-

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tions (B) may begin at the top surface of the radiation passing layer 2 on which there may be a buildup or residue (on the exterior surface of the electronic device). This build-up or residue may be due to contact with a user's skin during normal use of the device, which may leave an oily film that also catches dust particles, thereby leaving a build-up which may facilitate the undesired internal reflections (B) within the radiation passing layer 2. The absorber 8 may be expected to significantly attenuate such undesired reflections, without inhibiting the desired reflections, such as those depicted as "A", from reaching the detector 4. In other words, the absorber 8 helps in reducing the stray radiation that would otherwise be able to get around the shield 7 via the path "B" as shown (and impinge on the detector 4). This may help the proximity sensor circuitry 5 to operate more accurately when providing a measure of the external object scattered or reflected radiation.

In one embodiment, the absorber 8 has the following characteristics in an infrared band 700 nm to 1,100 nm: transmittance less than five percent (5%), and reflectance less than ten percent (10%). Such characteristics may be achieved by a film or sheet that is made of polyester or plastic. More generally, the film or sheet should have greater infrared absorption characteristics than the radiation shield 7 (for the same thickness and its other dimensions). In one instance, the absorber 8 is made of a film or sheet that is of a different material than the shield 7. The shield 7 may need to achieve other purposes (such as strength and low cost) that might sacrifice its radiation absorption characteristics. For instance, the shield 7 may be particularly rigid (e.g., made of metal or a high strength plastic) and therefore unable to function as a radiation absorbing seal while being directly in contact with the bottom surface of the radiation passing layer 2. One reason may be that it cannot conform sufficiently to the bottom surface of the radiation passing layer 2 in a horizontal plane, in order to avoid any gaps. The presence of gaps may allow radiation to pass between the emitter side and the detector side, in the form of internal reflections that are not sufficiently attenuated. Another reason for the inadequacy of the shield 7 acting by itself may be that it is of a material that does not have sufficiently high radiation absorption characteristics. By combining the shield 7 and the absorber 8, together they may form a barrier that has essentially no radiation gaps between the bottom surface of the light passing layer at one end, and the emitter and/or detector at another end.

As depicted in FIG. 5, the absorber may be formed as a mask that has two holes formed therein at positions that are directly above the emitter 3 and the detector 4 (once installed in position). It may be a film or sheet that is to be joined to the bottom surface of the radiation passing layer 2, and/or to the top surface of the shield 7. For instance, the sheet may be attached by an intermediate adhesive layer, such as a double-sided piece of tape or a thin layer of infrared transmissive adhesive fluid; as a film it may be deposited or rolled onto the bottom surface of the radiation passing layer 2 in the form of a liquid or gel which is then allowed to cure while in contact with the top surface of the shield 7. Other ways of manufacturing the stacked arrangement of the radiation passing layer 2, the absorber 8, and the shield 7 may be possible.

Turning now to FIG. 2, an example mobile device 10 in which an embodiment of the invention can be implemented is shown. This particular example is a smart phone having an exterior housing that is shaped and sized to be suitable for use as a mobile telephone handset. The mobile device 10 may be a personal wireless communications device that allows two-way real-time conversations (generally referred to as calls) between a near-end user that may be holding the device 10

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against her ear, and a far-end user. There is a connection over one or more communications networks between the mobile device **10** and a counterpart device of the far-end user. Such networks may include a wireless cellular network or a wireless local area network as the first segment, and any one or more of several other types of networks such as transmission control protocol/internet protocol (TCP/IP) internetworks and plain old telephone system networks. The near-end user listens to the call using an earpiece speaker located within the housing of the device and that is acoustically coupled to an acoustic aperture **12** formed near the top of the housing. The near-end user's speech may be picked up by a microphone whose acoustic aperture **9** is located near the bottom of the housing. Also included in the housing are conventional electronic components such as an audio codec circuit that interfaces transducers such as the speaker and the microphone with digital audio signal processing components. The audio codec circuitry may also allow the user to listen to the call through a wireless or wired headset that is connected to the handset portion of the mobile device **10**. The call may be conducted by establishing a connection through a wireless network, with the help of RF communications circuitry coupled to an antenna that are also integrated in the housing of the device **10**.

A user interacts with the mobile device **10** in this case by way of a touch screen that is formed in the front exterior face or surface of the housing. The touch screen may be below the acoustic aperture **12** (earpiece speaker), and above the acoustic aperture **9** (microphone). As an alternative, a physical keyboard may be provided together with a display-only screen, as used in earlier cellular phone devices. As another alternative, the housing of the mobile device **10** may have a moveable component, such as a sliding and tilting front panel, or a clamshell structure, instead of the chocolate bar type depicted. FIG. 2 also depicts a graphical user interface of a telephony application program that is running in the device **10** (e.g., stored in non-volatile solid state memory and being executed by an applications processor). The graphical user interface causes a virtual telephone keypad to be displayed as shown, together with related virtual buttons that can be actuated by touch events of the near-end user initiating a call, accessing a stored contacts list of the user, and accessing a voicemail box of the user.

In one instance, the wireless telephony handset (shown here as the mobile device **10**) has a structural layer **11** that may be a rigid, visible light transparent plate that begins at the top of the housing as shown and may extend down towards the bottom, forming most of the exterior front face of the housing and acting as a protective cover for the touch screen. The structural layer **11** is an infrared light passing layer whose top face is part of the exterior face of the housing, and whose bottom face is inside the housing (not shown). In this case, the structural layer **11** also serves as an outer protective layer of the touch screen and is therefore transparent in the visible band as well. A proximity sensor having an infrared emitter and an infrared detector both positioned below the bottom face of the structural layer **11**, inside the housing, are located directly underneath the apertures indicated by dotted lines in FIG. 2. In the plane defined by the front exterior face of the mobile device **10**, these infrared apertures are located above the virtual telephone keypad that is being displayed by the touch screen, closer to the acoustic aperture **12** (earpiece speaker) than the acoustic aperture **9** (microphone). A sectional view of a relevant region inside housing along the lines A, A' is shown in FIG. 3.

As seen in FIG. 3, the acoustic aperture **12** is formed in the structural layer **11**, to the side of a region through which

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infrared radiation will pass for operation of the proximity sensor. An internal frame member **14** is positioned between the emitter **3** and the detector **4**, where the frame member **14** (as an instance of the shield **7**, see FIG. 1) serves to block infrared radiation between the emitter and the detector. In addition, the internal frame member **14** may be designed (with the appropriate size and shape, as well as material) to assist in maintaining a rigid overall housing structure, by serving as a weight bearing column or wall, against the bottom surface of the structural layer **11**. The frame member **14** extends upwards to the bottom face of the structural layer **11** where it meets a radiation absorber **8** formed between a top surface of the frame member **14** and the bottom surface of the structural layer **11**. The frame member extends continuously upward and joins the bottom face of the structural layer **11** through the absorber **8**, in order to form a wall that has no infrared radiation gaps between the bottom surface of the structural layer **11** and the emitter and detector. In this case, the frame member has a T-shaped cross section as shown, where the absorber **8** conforms to the top of the T-shape cross-section. The absorber **8** (as described above in connection with FIG. 1) serves to absorb the internally reflected infrared radiation (originating as rays "B" that would otherwise make their way to the detector **4** as indicated by a dotted line), where such may have been caused by buildup or residue shown on the top face of the structural layer **11**. This reduces the amount of stray radiation that impinges on the detector **4**, which may increase the accuracy of the proximity sensor. Note that the emitter **3** and the detector **4** have been installed, in this example, on the same microelectronic or printed circuit board carrier, which may be a rigid printed circuit board piece. Other options for installing these components of the proximity sensor within the housing of the mobile device **10** are possible.

In this case, the proximity sensor arrangement, including the absorber **8**, has been integrated in the mobile device **10** in such a way as to provide the mobile device **10** with an external look that is uniformly dark. This may be achieved by the following arrangement of layers. A visible light opaque layer **13** (that may have a dark color such as black) is formed in contact with the bottom face of the structural layer **11**, with an opening therein aligned with the emitter **3** and another opening aligned with the detector **4**. The layer **13** may be a black ink layer (which is opaque in the visible band) that has been deposited or rolled onto the bottom surface of the structural layer **11** and allowed to cure, while the openings have been masked off. This layer **13** gives the exterior face of the device **10** a uniform and dark look from the outside (as the structural layer **11** may be transparent in the visible band). A purpose of the openings in the layer **13** is to allow infrared radiation to pass, as needed by the proximity sensor, because the black ink layer may not have sufficient transmissivity in the infrared band. Next, an IR transmissive layer **15** that is opaque in the visible band is applied to the bottom surface of the layer **13** as shown, also filling the openings therein. The IR transmissive layer **15** may be a film of IR transparent paint (also referred to as IR transmissive paint or ink, e.g. a dark or black ink) that has been deposited or rolled onto the back of bottom face of the structural layer **11**. The layer **15** serves to give a uniform appearance to the exterior face of the housing, by hiding the openings that have been formed in the layer **13**. Next, the absorber **8** is applied over the IR transmissive layer **15** as shown. As described above in connection with FIG. 1, the absorber **8** may include a Mylar® film or sheet that is separate from but has been joined to the bottom surface of the structural layer **11** (in this case over the visibly opaque layer **13** and the IR transmissive layer **15**); alternatively, it may be joined to

the top surface of the frame member **14**, prior to being brought into contact with the bottom of the structural layer **11**. The film or sheet may be a polyester film or a plastic sheet that has greater infrared absorption characteristics than that of the frame member **14**, for the same dimensions, e.g. thickness in the vertical direction. For instance, the absorber may have a transmittance of less than five percent (5%) and a reflectance of less than ten percent (10%), in an infrared band 700 nm to 1,100 nm. As an alternative, the infrared band may be slightly wider or narrower, but the transmittance should be about less than 5% and the reflectance should be about less than 10% in such bands.

FIG. 4 shows another embodiment of the invention where the absorber **8** is composed of an infrared passing adhesive layer **16** (e.g., an optically clear adhesive fluid) in contact with the top face of an absorbing layer **17** (e.g., a Mylar® sheet patterned as shown in FIG. 5). The adhesive fluid may be an index matching material that reduces differences in index of refraction (within the infrared band used by the proximity sensor) between the absorber **8** and the radiation passing layer **2** or structural layer **11**. The two holes may actually be physical holes made only in the absorbing layer **17**, and not in the infrared passing adhesive layer **16**, and are aligned with the locations of the emitter **3** and the detector **4** (which may be directly below these holes). Alternatively, the adhesive layer **16** may be applied only to the top face of the patterned piece (absorbing layer **17**). The absorber **8** is then pressed against the bottom surface of the radiation passing layer **2** or structural layer **11**, to form the arrangement as shown. Note also a difference in this case, relative to the embodiment of FIG. 3, in that there is a single, larger opening formed in the visibly opaque layer **13**, which encompasses the emitter and the detector regions as well as the separating region between them. Accordingly, the visibly opaque infrared transmissive layer **14** will in this case fill the entirety of such opening as shown, in order to maintain the desired uniform dark look from the exterior. The structure in FIG. 4 may be otherwise the same as that of FIG. 3.

What has been described above is an electronic device having an external housing in which the constituent components of the device are located, a radiation passing layer or structural layer (also referred to here as a cover) that physically protects the electronic components while allowing radiation to pass therethrough, a proximity sensor that transmits radiation out of the housing and receives radiation that has been scattered outside of the housing, and a shield that blocks stray radiation from impinging on the detector portion of the proximity sensor. An absorber is positioned between the shield and the bottom surface of the cover in a way that removes radiation gaps and serves to take up stray radiation, that may be due to internal reflections within cover, such as those caused by smudge on the exterior face of the cover, in order to prevent such from impinging on the detector portion of the sensor. A method for manufacturing such an electronic device may proceed as follows.

Referring to FIG. 3 and FIG. 4, a bottom or rear face of a transparent cover or cap (an instance of the structural layer **11** or radiation passing layer **2**) is prepared to receive a coat of visibly opaque (dark) paint thereon. One or more paint masks that are located directly above the positions of an emitter and a detector of a proximity sensor are applied to the prepared surface. The dark paint layer is then applied and allowed to cure. The mask is removed thereby exposing the bottom surface of the cover at the IR apertures, which will be located directly above the emitter and the detector. A visibly opaque infrared transmissive layer (e.g., a coat of IR transmissive black ink) is applied to the exposed IR apertures, and is then

allowed to cure. Finally, an absorber is applied as either a single film or as a multi-layer structure, with openings that are aligned with those in the original black paint layer. For instance, an IR clear adhesive may be applied to a top face of an IR absorbing layer **17** that has separate physical openings formed therein for the emitter and the detector, which is then adhered to the IR transmissive layer **15**. Alternatively, the IR clear adhesive may be applied to the bottom of the cover (over the IR transmissive layer **15**), and then the IR absorbing layer **17** is pressed onto the bottom of the cover against the adhesive. Additional operations may be needed prior to the above or thereafter, before the cover has been completed and is ready to be installed into the housing. At that point, the cover is positioned into the housing, with its IR apertures and openings aligned to the emitter and the detector locations, and is brought into contact with the top surface of the internal frame member **14**. The cover is then fixed in that position and becomes the exterior front face of the housing.

While certain embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that the invention is not limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those of ordinary skill in the art. For example, although the manufacturing process has been described in connection with the embodiments of FIG. 3 and FIG. 4, a similar process can be gleaned for the embodiment of FIG. 1 in which no visibly opaque layers may be necessary. Also, while the drawings depict different layers being in contact with each other (e.g., in FIG. 3, layer **13** is in contact with the bottom of layer **11**, and the absorber is in contact with the layer **15**), this does not preclude an additional or intermediate layer between them so long as the purposes of the radiation seal achieved by the absorber **8**, including that of attenuating the stray internal reflections within the layer **11**, are not thwarted. The description is thus to be regarded as illustrative instead of limiting.

What is claimed is:

1. An electronic device comprising:

a radiation passing layer having a top surface and a bottom surface;

a proximity sensor having a radiation emitter and a radiation detector, both positioned below the radiation passing layer;

a radiation shield positioned between the emitter and the detector, and extending to the bottom surface of the radiation passing layer; and

a radiation absorber being a separate piece and of a different material than the shield and positioned to provide a radiation seal between a top surface of the shield and the bottom surface of the radiation passing layer wherein the absorber is formed as a mask that has two holes formed therein directly above the emitter and the detector, respectively.

2. The device of claim 1 wherein the absorber comprises a film or sheet that is separate from but that has been joined to at least one of the bottom surface of the radiation passing layer and the top surface of the shield.

3. The device of claim 2 wherein the film or sheet is of a different material than the shield.

4. The device of claim 2 wherein the film or sheet is made of a material that has greater infrared absorption characteristics than that of the radiation shield.

5. The device of claim 2 wherein the film or sheet is one of a polyester film and a plastic sheet.

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6. The device of claim 1 wherein the absorber has the following characteristics in an infrared band 700 nm to 1100 nm: transmittance less than 5% and reflectance less than 10%.

7. An electronic device comprising:

a wireless telephony handset housing having an infrared light passing layer whose top face is part of an exterior face of the housing and whose bottom face is inside the housing;

a proximity sensor having an infrared emitter and an infrared detector both positioned below the bottom face of the light passing layer, inside the housing;

an internal frame member positioned between the emitter and the detector, the frame member to block infrared radiation between the emitter and the detector; and

an infrared absorber being a mask that is of a different material than the frame member and has two holes formed therein, wherein the mask is positioned between a top surface of the frame member and the bottom surface of the light passing layer such that the two holes are directly above the emitter and the detector, respectively.

8. The device of claim 7 wherein the internal frame member extends continuously upward and joins the bottom face of the light passing layer through the infrared absorber.

9. The device of claim 7 further comprising an earpiece speaker and a microphone both inside the housing, a top face to bottom face acoustic aperture formed in the light passing layer and acoustically coupled to the earpiece speaker, and wherein the proximity sensor is positioned closer to the aperture than the microphone.

10. The device of claim 7 wherein the light passing layer is flat, the frame member has a T-shape, and the absorber conforms to a top of the T-shape.

11. The device of claim 7 wherein the absorber comprises a film or sheet that is separate from but that has been joined to at least one of the bottom surface of the light passing layer and the top surface of the frame member.

12. The device of claim 11 wherein the film or sheet is one of a polyester film and a plastic sheet that has been bonded to the light passing layer via an adhesive containing an index-matching material.

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13. The device of claim 11 wherein the film or sheet is made of a material that has greater infrared absorption characteristics than that of the frame member.

14. The electronic device of claim 7 wherein the absorber has the following characteristics in an infrared band 700 nm to 1100 nm: transmittance less than 5% and reflectance less than 10%.

15. The electronic device of claim 7 further comprising a touch screen whose top face is part of the exterior face of the housing, and whose bottom face is inside the housing.

16. The electronic device of claim 15 wherein the infrared light passing layer forms part of and is an outer protective layer of the touch screen as well as a structural layer of the housing.

17. The electronic device of claim 7 further comprising: a visible light opaque layer in contact with a bottom face of the light passing layer and having an opening therein aligned with one of the emitter and the detector; and an infrared transmissive layer in contact with the bottom face of the light passing layer within said opening, to give a uniform appearance to the exterior face of the housing.

wherein the absorber is joined to the infrared transmissive layer.

18. A method for manufacturing an electronic device, comprising:

applying an infrared absorber being a mask having two holes formed therein, to the bottom surface of a radiation passing layer; and then

positioning the radiation passing layer into an exterior housing of a mobile device and fixing the radiation passing layer in place while the absorber is in contact with a top surface of an internal frame member in the housing that lies between an infrared emitter and an infrared detector of a proximity sensor in the housing, such that the two holes of the mask are aligned with a radiation passage for the emitter and the detector, respectively.

19. The method of claim 18 wherein the absorber has the following characteristics in an infrared band 700 nm to 1100 nm, namely transmittance less than 5% and reflectance less than 10%.

\* \* \* \* \*



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**Tam**

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(45) **Date of Patent:** **\*Apr. 29, 2014**

(54) **PROXIMITY SENSOR ARRANGEMENT IN A MOBILE DEVICE**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 504 days.

This patent is subject to a terminal disclaimer.

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(57) **ABSTRACT**

A radiation passing layer has a top surface and a bottom surface below which a proximity sensor is positioned. A radiation shield is between the emitter and the detector, and extends to the bottom of the radiation passing layer. A radiation absorber being a separate piece and of a different material than the shield is positioned to provide a radiation seal between the top surface of the shield and the bottom surface of the radiation passing layer. Other embodiments are also described and claimed.

**19 Claims, 3 Drawing Sheets**

