(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 April 2014 (17.04.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/058492 A1

(51) International Patent Classification:
G06F 3/033 (2013.01)

(21) International Application Number:
PCT/US2013/050173

(22) International Filing Date:
12 July 2013 (12.07.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

61/713,546	14 October 2012 (14.10.2012)	US
13/732,456	2 January 2013 (02.01.2013)	US
13/775,269	25 February 2013 (25.02.2013)	US

(71) Applicant: **NEONODE INC.** [US/US]; 2350 Mission College Blvd., Suite 190, Santa Clara, CA 95054 (US).

(72) Inventors: **ERIKSSON, Thomas**; Döbelnsgatan 25, S-113 58 Stockholm (SE). **HOLMGREN, Stefan**; Vespergränd 24, S-192 72 Sollentuna (SE). **KARLSSON, John**; Tingvallavägen 16A, S-195 32 Märsta (SE). **BEHDASHT, Remo**; De Oude Klarenbeek 10, NL-7339 EZ Ugchelen (NL). **ROSENGREN, Erik**; Körsbärsvägen 9, S-114 23 Stockholm (SE). **SPARF, Lars**; Rödarvsgränd 14, S-162 45 Vällingby (SE).

(74) Agent: **BERGER, Marc, A.**; Soquel Group LLC, P.O. Box 691, Soquel, CA 95073 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

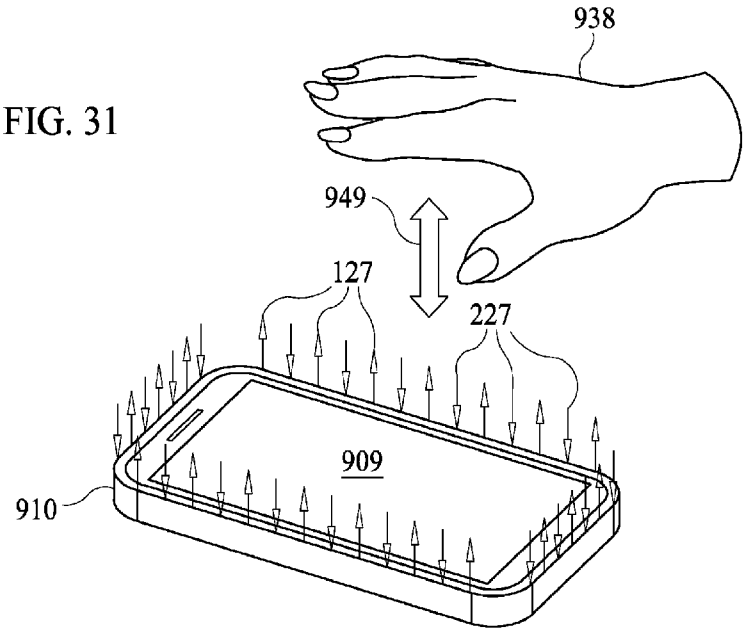
Published:

— *with international search report (Art. 21(3))*

[Continued on next page]

(54) Title: LIGHT-BASED PROXIMITY DETECTION SYSTEM AND USER INTERFACE

FIG. 31



(57) Abstract: A removable cover for a handheld electronic device, including a protective cover that at least partially covers rear and side surfaces of a handheld electronic device, a plurality of proximity sensors mounted in the cover for detecting user gestures performed outside of the electronic device, a battery, wireless communication circuitry, and a processor configured to operate the proximity sensors, and to operate the wireless communication circuitry to transmit commands to the electronic device based on gestures detected by the proximity sensors.

WO 2014/058492 A1

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

LIGHT-BASED PROXIMITY DETECTION SYSTEM AND USER INTERFACE

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application claims priority benefit of U.S. Patent Application Serial No. 13/775,269, entitled REMOVABLE PROTECTIVE COVER WITH EMBEDDED PROXIMITY SENSORS, filed on February 25, 2013 by inventors Thomas Eriksson, Stefan Holmgren, John Karlsson, Remo Behdasht, Erik Rosengren and Lars Sparf, the contents of which are hereby incorporated herein in their entirety.

[0002] This application claims priority benefit of U.S. Patent Application Serial No. 13/732,456, entitled LIGHT-BASED PROXIMITY DETECTION SYSTEM AND USER INTERFACE, filed on January 3, 2013 by inventors Thomas Eriksson and Stefan Holmgren, the contents of which are hereby incorporated herein in their entirety.

[0003] This application claims priority benefit of U.S. Provisional Patent Application Serial No. 61/713,546, entitled LIGHT-BASED PROXIMITY DETECTION SYSTEM AND USER INTERFACE, filed on October 14, 2012 by inventor Stefan Holmgren, the contents of which are hereby incorporated herein in their entirety.

FIELD OF THE INVENTION

[0004] The field of the present invention is light-based proximity sensors, graphical user interfaces and wireless input devices.

BACKGROUND OF THE INVENTION

[0005] Conventional touch sensitive virtual buttons, i.e., buttons painted on a stationary flat surface and actuated by touch, are capacitance-based or resistance-based. Certain touch sensitive user input systems detect hovering objects as well. Examples include U.S. Publication No. 2008/0012835 A1 for HOVER AND TOUCH DETECTION FOR DIGITIZER and U.S. Publication No. 2006/0244733 A1 for TOUCH SENSITIVE DEVICE AND METHOD USING PRE-TOUCH INFORMATION.

[0006] Prior art hover detection systems based on reflected light determine a height of an object above a surface based on an amount of reflected light: the nearer the object - the more light is reflected onto the detector situated beneath the touch surface. Therefore, prior art systems are able to detect a hovering object over time and determine whether the object is moving closer or farther away based on relative amounts of detected light. I.e., diminishing light detection over time indicates an object moving away from the surface, and increasing light detection over time indicates an object moving toward the surface. In other words, the determined height is relative to other heights in a series of detections, but the actual height remains unknown. Indeed, different materials reflect different amounts of light, e.g., a white glove reflects more light than a black glove, and the reflective properties of a hovering object are not known by the system. Therefore, the system cannot determine the height at which the object is situated above the surface based on the amount of reflected light detected. In addition, because prior art proximity detectors require a series of detections of the object at different heights in order to rank the heights in relation to each other, a single proximity detection or a series of detections of a stationary hovering object will provide little information about the height of the object.

[0007] Graphical user interfaces (GUIs) enable interaction with visual elements displayed on a screen. When the extent of a GUI exceeds that of the screen, a user is restricted to interacting with only the portion of the GUI that is displayed on the screen. In order to activate a visual element virtually located outside of the displayed portion of the GUI, the user must pan the GUI, moving a portion of the GUI from outside of the display into the display, while displacing a currently displayed portion of the GUI out of the display. It would thus be of advantage to enable user interactions with GUI elements that are virtually located beyond the display area of the screen, without panning the GUI.

[0008] Wireless communication is the transfer of data between two or more devices that are not connected by a physical conductor. Common wireless technologies use electromagnetic wireless telecommunication, including inter alia radio. BLUETOOTH® is a wireless technology standard for exchanging data over short distances, using short wavelength radio transmission in the ISM band from 2400 – 2480 MHz. Two popular wireless applications are a hands-free headset for controlling a mobile phone, and a wireless mouse for a personal computer.

SUMMARY

[0009] Aspects of the present invention relate to touch sensitive surfaces used to implement switches or slider controls for handheld devices such as mobile phones, office equipment such as printers and multi-function peripheral devices, and household appliances such as washing machines and microwave ovens. Additional user interfaces and devices are disclosed hereinbelow.

[0010] Further aspects of the present invention relate to GUIs and, in particular, to user interaction with GUI elements that are virtually located beyond the extent of the display screen.

[0011] Further aspects of the present invention relate to GUIs for applications running on a device, which respond to tap and slide gestures along outside edges of the device, and to hand wave gestures above the device.

[0012] Further aspects of the present invention relate to a removable protective device cover that includes proximity sensors, for detecting user gestures performed outside of the device, including contact user gestures performed on a surface of the cover, and non-contact user gestures performed in the air, in the vicinity of the device.

[0013] Further aspects of the present invention relate to a removable protective device cover that is in wireless communication with the covered device. The protective device cover includes proximity sensors for detecting user gestures performed outside of the device, and communicates the detected gestures to the device via a wireless communication protocol such as BLUETOOTH®. In this manner, a user controls the device through gestures detected by the protective cover.

[0014] There is thus provided in accordance with an embodiment of the present invention an electronic device, including a housing, a display mounted in the housing, a plurality of proximity sensors mounted in the

housing near the edges of the display and directed outward from the display, for detecting presence of an object outside the display and near the edges of the display, and a processor mounted in the housing and coupled with the display and with the proximity sensors, for operating the device responsive to user activation of elements of a graphical user interface (GUI), the GUI including a displayed portion that is rendered by the processor on the display, and a virtual non-displayed portion that extends beyond the edges of the display, wherein the processor operates the device responsive to user activation of elements of the virtual portion of the GUI, based on the proximity sensors detecting presence of an object in the non-displayed portion of the GUI.

[0015] There is additionally provided in accordance with an embodiment of the present invention a camera, including a housing, a viewfinder mounted in the housing, a plurality of proximity sensors mounted in the housing near the edges of the viewfinder and directed outward from the viewfinder, for detecting presence of a finger outside the viewfinder and near the edges of the viewfinder, and a processor mounted in the housing and coupled with the viewfinder and with the proximity sensors, wherein the processor causes the camera to capture a current frame in the viewfinder in response to a user tap at a first location on the outside of the edges of the viewfinder, based on the proximity sensors detecting presence of a finger.

[0016] There is further provided in accordance with an embodiment of the present invention an electronic device, including a housing, a display mounted in the housing, a plurality of proximity sensors mounted in the housing near the edges of the display and directed outward from the display, for detecting presence of an object outside the display and near the edges of the display, and a processor mounted in the housing and coupled with the display and with the proximity sensors, for operating the

device responsive to user activation of a virtual control located along the outside of an edge of the device, wherein the processor operates the device responsive to user activation of the virtual control, based on the proximity sensors detecting presence of an object at the outside the edge of the device.

[0017] There is yet further provided in accordance with an embodiment of the present invention an electronic device, including a housing, a display mounted in the housing, a plurality of proximity sensors mounted in the housing near the edges of the display and directed upwards from the display, for detecting presence of an object above the display, and a processor mounted in the housing and coupled with the display and to said proximity sensors, wherein the processor operates the device responsive to a user wave gesture above the display, based on the proximity sensors detecting presence of an object above the display.

[0018] There is moreover in accordance with an embodiment of the present invention an electronic device, including a housing, a display mounted in the housing, a plurality of proximity sensors mounted in the housing near the edges of the display and directed outward from the display, for detecting presence of an object outside the display and near the edges of the display, and a processor mounted in the housing and coupled with the display and with the proximity sensors, for operating the device responsive to user activation of elements of a graphical user interface (GUI), the GUI including a displayed portion that is rendered by the processor on the display, and a virtual non-displayed portion that extends beyond the edges of the display, wherein the processor operates the device responsive to user activation of elements of the virtual portion of the GUI, based on the proximity sensors detecting presence of an object in the non-displayed portion of the GUI.

[0019] There is additionally provided in accordance with an embodiment of the present invention a camera, including a housing, a viewfinder mounted in the housing, a plurality of proximity sensors mounted in the housing near the edges of the viewfinder and directed outward from the viewfinder, for detecting presence of a finger outside the viewfinder and near the edges of the viewfinder, and a processor mounted in the housing and coupled with the viewfinder and with the proximity sensors, wherein the processor causes the camera to capture a current frame in the viewfinder in response to a user tap at a first location on the outside of the edges of the viewfinder, based on the proximity sensors detecting presence of a finger.

[0020] There is further provided in accordance with an embodiment of the present invention an electronic device, including a housing, a display mounted in the housing, a plurality of proximity sensors mounted in the housing near the edges of the display and directed outward from the display, for detecting presence of an object outside the display and near the edges of the display, and a processor mounted in the housing and coupled with the display and with the proximity sensors, for operating the device responsive to user activation of a virtual control located along the outside of an edge of the device, wherein the processor operates the device responsive to user activation of the virtual control, based on the proximity sensors detecting presence of an object at the outside the edge of the device.

[0021] There is yet further provided in accordance with an embodiment of the present invention an electronic device, including a housing, a display mounted in the housing, a plurality of proximity sensors mounted in the housing near the edges of the display and directed upwards from the display, for detecting presence of an object above the display, and a processor mounted in the housing and coupled with the display and to

said proximity sensors, wherein the processor operates the device responsive to a user wave gesture above the display, based on the proximity sensors detecting presence of an object above the display.

[0022] There is moreover provided in accordance with an embodiment of the present invention a removable cover for a handheld electronic device, including a protective cover that at least partially covers rear and side surfaces of a handheld electronic device, a plurality of proximity sensors mounted in the cover for detecting user gestures performed outside of the electronic device, a battery, wireless communication circuitry, and a processor configured to operate the proximity sensors, and to operate the wireless communication circuitry to transmit commands to the electronic device based on gestures detected by the proximity sensors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The present invention will be more fully understood and appreciated from the following detailed description, taken in conjunction with the drawings in which:

[0024] **FIG. 1** is a simplified illustration of a proximity sensor having one emitter-detector channel, in accordance with an embodiment of the present invention;

[0025] **FIG. 2** is a simplified illustration of a first configuration of a proximity sensor having two emitter-detector channels, in accordance with an embodiment of the present invention;

[0026] **FIG. 3** is a simplified illustration of a second configuration of a proximity sensor having two emitter-detector channels, in accordance with an embodiment of the present invention;

[0027] **FIGS. 4** and **5** are simplified diagrams of a touch sensitive slider window featuring multiple emitter-detector channels that detect a location of a finger along the length of the window, in accordance with an embodiment of the present invention;

[0028] **FIG. 6** is a simplified illustration of a finger placed along the touch sensitive slider window of **FIGS. 4** and **5**, in accordance with an embodiment of the present invention;

[0029] **FIGS. 7** - **10** are simplified diagrams showing different views of a touch sensitive slider window featuring multiple emitter-detector channels that detect a location of a finger along the length of the window, in accordance with an embodiment of the present invention;

[0030] **FIGS. 11** - **13** are simplified diagrams of a touch sensitive slider window featuring two emitter-detector channels that detect a location of a finger along the height of the window, in accordance with an embodiment of the present invention;

[0031] **FIG. 14 – 17** are simplified diagrams of a configuration of a touch sensitive window featuring four emitter-detector channels operative to detect a glide movement in both horizontal and vertical directions, in accordance with an embodiment of the present invention;

[0032] **FIGS. 18 - 19** are simplified illustrations of top-shooting diodes in a configuration of a touch sensitive window featuring four emitter-detector channels operative to detect a glide movement in both horizontal and vertical directions, in accordance with an embodiment of the present invention;

[0033] **FIGS. 20** - **22** are simplified diagrams of hovering gestures using the touch sensitive window of **FIGS. 4** and **5**, in accordance with an embodiment of the present invention;

[0034] **FIG. 23** is a simplified diagram of an electronic device with proximity sensors along all four device edges, in accordance with an embodiment of the present invention;

[0035] **FIG. 24** is a simplified illustration of a user interface for a music application, in accordance with an embodiment of the present invention;

[0036] **FIG. 25** is a simplified illustration of a user interface for a drum application, in accordance with an embodiment of the present invention;

[0037] **FIG. 26** is a flow chart of a method for providing a graphical user interface (GUI), in accordance with an embodiment of the present invention;

[0038] **FIG. 27** is a simplified illustration of a user interface for a shooter game, in accordance with an embodiment of the present invention;

[0039] **FIG. 28** is a simplified illustration of a user interface for a car racing game, in accordance with an embodiment of the present invention;

[0040] **FIG. 29** is a simplified illustration of a user interface for a music player application, in accordance with an embodiment of the present invention;

[0041] **FIG. 30** is a simplified diagram of an electronic device with proximity sensors along all four device edges, in accordance with an embodiment of the present invention;

[0042] **FIG. 31** is a simplified diagram of a user interface "bounce" gesture performed on the electronic device of **FIG. 30**, in accordance with an embodiment of the present invention;

[0043] **FIG. 32** is a simplified illustration of a user interface for an alarm clock application, in accordance with an embodiment of the present invention;

[0044] **FIG. 33** is a simplified illustration of a user interface for a camera application, in accordance with an embodiment of the present invention;

[0045] **FIG. 34** is a simplified illustration of a removable cover attached to a handheld electronic device, in accordance with an embodiment of the present invention;

[0046] **FIG. 35** is an exploded view of the removable cover of **FIG. 34**, in accordance with an embodiment of the present invention;

[0047] **FIG. 36** is an assembled view of the removable cover of **FIG. 34**, in accordance with an embodiment of the present invention;

[0048] **FIG. 37** is a top perspective view of the removable cover of **FIG. 34**, in accordance with an embodiment of the present invention;

[0049] **FIG. 38** is a bottom perspective view of the removable cover of **FIG. 34**, in accordance with an embodiment of the present invention; and

[0050] **FIG. 39** is a schematic layout of the printed circuit board in the removable cover of **FIG. 34**, in accordance with an embodiment of the present invention.

[0051] In this specification and in the figures, the following numbering scheme is used. Light emitting elements and emitted light beams are numbered in the range of **100** - **199**. Light receiving elements such as PDs, and reflected light beams are numbered in the range of **200** – **299**. Lens components, reflective and refractive elements are numbered in the range of **300** – **399**. Fingers, styli, electronic devices and their housings are numbered in the range of **900** – **999**.

[0052] The following tables catalog the numbered elements and list the figures in which each numbered element appears.

Emitters and Emitter Beams		
Element	**Figures**	**Description**
110 – 114, 123, 124, 126, 127	**1 – 3, 7, 8, 12, 23, 30, 31**	emitter beams
121 - 125	**4, 7 - 13, 15, 16, 18, 37 - 39**	emitters

Receivers and Receiver Beams		
Element	**Figures**	**Description**
210 – 213, 223 - 227	**1, 30, 31**	receiver beams
221, 221.1, 221.2, 221.3, 221.4, 222	**4 – 6, 37, 38**	receivers

Lenses		
Element	**Figures**	**Description**
301 - 303	**4 – 12, 14**	lenses
303.1 – 303.3	**15 - 17**	lens section
310	**20 - 22**	control window
320	**17**	diagonal face

Miscellaneous Elements		
Element	**Figures**	**Description**
900 - 905	**1 - 3, 6, 20 – 22, 24, 25, 27, 33**	fingers
906	**24**	turntable
907, 908	**24**	slider
909	**20 - 23, 30, 32**	screen
910	**1 - 3, 20 - 23, 30 - 35**	device
911 - 913	**25**	drum
914, 915	**25**	cymbal
916	**25**	extension of drum
917, 918	**25**	extension of cymbal
920	**27**	shooter game
921, 922	**4 - 10**	upper casing part
923	**4 - 10**	PCB
924	**9, 10**	isolating barrier
925	**27**	gun sight
926	**27**	left arrow
927	**27**	right arrow
928 - 930	**27**	gun
931, 941	**11, 14 – 17**	upper casing part
932, 942	**11, 14 - 17**	lower casing part
933	**28**	car racing game
934	**28**	steering wheel
936	**29**	MP3 player
937	**29**	Stereo dock
938	**29, 31, 32**	hand
939, 946 – 949, 954, 955, 957, 964, 965	**20 – 22, 29, 31, 32, 33**	arrow
943	**16**	PCB
945	**17**	air gap
950	**19**	light transmissive cover
951	**19**	cross shape
970	**34 - 38**	protective cover
972	**35 - 38**	front housing panel
973	**35, 37**	rear housing panel
974	**35 - 38**	battery
976	**35 - 38**	printed circuit board
978, 979	**35 - 38**	series of lenses
980, 982	**34 – 36, 38**	touch slider
981	**34**	touch slider length
985	**37, 39**	emitter / receiver driver
986	**37, 39**	CPU
987	**39**	BLUETOOTH(R) antenna
990	**38, 39**	power socket
992, 993	**38, 39**	control button

DETAILED DESCRIPTION

[0053] Aspects of the present invention relate to light-based touch controls such as virtual buttons, sliders and touch pads. Aspects of the present invention also relate to proximity sensors for hover gestures. According to embodiments of the present invention, a light-based touch control and proximity sensor includes infra-red light-emitting diodes (LEDs) and photodiodes (PDs) situated inside a housing for an electronic device, beneath an infra-red-transmissive section of the housing. The LEDs project light substantially incident to the housing surface, through the transmissive section. When an object touches or approaches the transmissive section, it reflects the light back into the housing where it is detected by the PDs. Each detection of reflected light represents a detection channel.

[0054] A proximity sensor having only one LED and one PD has a single detection channel that provides one signal. In principle this signal provides binary (yes/no) information as to whether or not an object is present above the sensor. In addition, this signal provides information as to a direction of movement of the object along the proximity axis, i.e., whether the object is moving toward the sensor or away from the sensor. Thus, if the signal increases over time, the object is moving toward the sensor, whereas if the signal decreases over time, the object is moving away from the sensor.

[0055] Reference is made to **FIG. 1**, which is a simplified illustration of a proximity sensor having one emitter-detector channel, in accordance with an embodiment of the present invention. **FIG. 1** illustrates an embodiment whereby one LED and one PD are situated together beneath a control surface embedded in the housing. In this embodiment one detection channel is provided.

[0056] **FIG. 1** shows a portable electronic device **910** in profile view. An emitter beam **110** is projected above the device and is reflected back into the device by a finger **900** placed above the device. Thus, the light channel **110** - **210** is provided to detect a proximal finger **900**.

[0057] As explained hereinabove, one example of the limitations of a single channel is that it is impossible determine a distance of the object from the sensor based on the strength of the detection signal since different objects can be used that have different reflective properties. For example, a black glove near the sensor and a white glove further away from the sensor provide substantially similar levels of detection. More channels generate more information. However, an extra channel does not necessitate adding an additional LED and an additional PD. Rather, several PDs can share the light from one LED to provide multiple detection channels. Similarly, one PD can provide multiple detection channels when it is able to receive reflected light from several LEDs.

[0058] Reference is made to **FIG. 2**, which is a simplified illustration of a first configuration of a proximity sensor having two emitter-detector channels, in accordance with an embodiment of the present invention. **FIG. 2** illustrates two LEDs and one PD situated in a row beneath a control surface embedded in the housing. This row of two LEDs and one PD has one of the LEDs placed between the other LED and the PD. In this embodiment two detection channels are provided. With two channels positional information along one dimension can be generated by interpolation.

[0059] **FIG. 2** shows a portable electronic device **910** in profile view and two emitter-detector light channels. Thus, **FIG. 2(A)** demonstrates a first light channel **112** - **212** that detects a near finger **901**; and **FIG. 2(B)** demonstrates a second light channel **111** - **211** that detects a more distal finger **900**. The emitter beams **111** and **112** issue forth from the

upper surface of device **910** at an angle in order that their respective reflected beams arrive at the location of the detector. The proximity detector of **FIG. 2** provides an indication of the height of the object based on which channel is detected. An interpolation of signals from the two channels will indicate a position of the object within the range of heights detected by both channels.

[0060] By contrast, prior art proximity detectors determine proximity based on a relative intensity of a reflected signal and require a series of detections in order to rank the different signals, as explained hereinabove. Thus, the system of **FIG. 2** addresses two shortcomings of the prior art: 1. it provides an indication of the absolute height of the object above the screen, as opposed to a relative height; and, 2. it provides this indication based on detections of a stationary object and does not require a series of detections over time.

[0061] Two similar detection channels are provided by two detectors and one emitter, for example by replacing the emitters of the **FIG. 2** system with detectors, and replacing the detector of the **FIG. 2** system with an emitter. In this case, beams **211** and **212** are one and the same emitter beam issued by the one emitter, and the reflected beam **111** or **112** arrives at one of the two detectors depending on the height of the finger **900** or **901** above the device **910**.

[0062] Reference is made to **FIG. 3**, which is a simplified illustration of a second configuration of a proximity sensor having two emitter-detector channels, in accordance with an embodiment of the present invention. **FIG. 3** shows a portable device **910** with two detection channels, but in this case the detector is situated between the two emitters and the two channels provide lateral position information. A first emitter beam **113** is projected above the device to the right of the detector, and a second emitter beam **114** is projected above the device to the left of the

detector. When a finger hovers above the space between the first emitter and the detector, as illustrated by finger **900** in **FIG. 3**, it creates a first detection channel **113** – **213**. When a finger hovers above the space between the second emitter and the detector, as illustrated by finger **901** in **FIG. 3**, it creates a second detection channel **114** – **213**. An interpolation of signals from the two channels indicates a position of the object between the outermost components. As explained hereinabove, the emitters and detectors may be swapped and still provide two similar detection channels.

[0063] Aspects of the invention relate to providing a thin window spanning the height or thickness of a device, such as a mobile phone. The user interacts with the phone by performing finger gestures against this window, and the proximity sensor detects the position or gesture of the finger. One application is to replace physical buttons. In the most basic case light from an LED is sent out of the device and reflected by the finger. The reflected light is detected by two PDs situated on either side of the LED and the position of the finger is interpolated from the signals. For instance such an arrangement may replace the volume buttons on a mobile phone. In principle such an arrangement may have limited proximity functionality. This conceptual model can be extended with additional components.

[0064] Reference is made to **FIGS. 4** and **5**, which are simplified diagrams of a touch sensitive slider window featuring multiple emitter-detector channels that detect a location of a finger along the length of the window, in accordance with an embodiment of the present invention. Reference is also made to **FIG. 6**, which is a simplified illustration of a finger placed along the touch sensitive slider window of **FIGS. 4** and **5**, in accordance with an embodiment of the present invention. **FIGS. 4** and **5** show front and back views of a touch sensitive slider window featuring

multiple emitter-detector channels that detect a location of a finger along the length of the window. **FIGS. 4** and **5** show a sidewall of a device housing formed by an upper casing part **921** and a lower casing part **922**. A lens **301** is wedged between casing parts **921** and **922**. **FIGS. 4** and **5**, and in particular **FIG. 4**, show a PCB **923** placed inside the device housing. Light emitters **121** and light detectors **221** are mounted in an alternating row on PCB **923**. Every emitter–detector pair of neighboring elements provides a detection channel for detecting an object touching the outer side edge of the housing along the length of lens **301**, as illustrated by finger **900** in **FIG. 6**.

[0065] When the emitters and detectors are placed together inside the housing, light scatters inside the housing when an emitter is activated and a portion of the scattered light arrives at the detectors without being reflected by an object outside lens **301**. In order to minimize the amount of scattered light that reaches the detectors, the emitters and detectors are mounted on PCB **923** facing opposite directions.

[0066] Reference is made to **FIGS. 7 – 10**, which are simplified diagrams showing different views of a touch sensitive slider window featuring multiple emitter-detector channels that detect a location of a finger along the length of the window, in accordance with an embodiment of the present invention. **FIGS. 7 – 10**, showing inward-facing emitters **122** and outward-facing detectors **222**. In addition, an isolating barrier **924** is placed between the emitters and the detectors to further shield the detectors from scattered light. **FIG. 9** is an exploded view of this configuration. **FIG. 10** is a cross-section view of the same configuration.

[0067] Lens **301** in **FIGS. 7 - 10** is more complex than lens **301** in **FIGS. 4** and **5**. In **FIGS. 7 - 10**, in order to direct light from the inward-facing emitters out through lens **301** and back onto the outward-facing detectors, lens **301** extends over and around the emitters **122** but not

the detectors **222**. Two light paths are shown in **FIGS. 7** and **8**. Emitter beam **123** is reflected twice inside lens **301** before it travels over emitter **122** and out of the device. Incoming beam **223** enters lens **301** and is reflected twice inside the lens before arriving at detector **222**.

[0068] Reference is made to **FIG. 11** – **13**, which are simplified diagrams of a touch sensitive slider window featuring two emitter-detector channels that detect a location of a finger along the height of the window, in accordance with an embodiment of the present invention. **FIGS. 11** – **13** illustrate another configuration of a two-channel control. In this case, the control detects objects along the height of the device rather than along the length of the device as in **FIGS. 3** - **10**. **FIGS. 11** – **13** show upper and lower casing parts **931** and **932**. One emitter **122** and two receivers **222** are connected to lower casing part **932**. The detection channels are made possible by a reflecting lens **302** inserted between casing parts **931** and **932**. The light path from emitter **122** through lens **302** is illustrated in **FIG. 12** as outgoing emitter beam **124**. The light paths of the two incoming beams **224** and **225** that are directed at the two detectors **222** are also illustrated in **FIG. 12**. **FIG. 13** is a cross-section view of lens **302** and the light beam paths **124**, **224** and **225** of **FIG. 12**.

[0069] With three channels, position information in two dimensions is obtained. One application is an optical joystick. A second application is a two-dimensional navigation pad. A third application is a mouse touchpad. For example, arranging three emitters at three corners of an equilateral triangle and placing a detector at the triangle's center of gravity provides three detection signals. By interpolating the signals, a two-dimensional location of the object is obtained. As a second example, begin with the two channels of **FIG. 2** to provide height information, and add one channel to provide lateral information as in **FIG. 3**.

[0070] Reference is made to **FIGS. 14 – 17**, which are simplified diagrams of a configuration of a touch sensitive window featuring four emitter-detector channels operative to detect a glide movement in both horizontal and vertical directions, in accordance with an embodiment of the present invention. **FIGS. 14 – 17** illustrate a cross-bar control for detecting up-down and right-left movements of a finger or other object. The illustrated control has four detection channels created by one central emitter **122** surrounded by four detectors **222.1** - **222.4**. An alternative configuration has one central detector surrounded by four emitters and is similar in operation to the system of **FIGS. 14 – 17**. **FIG. 14** shows a lens **303** situated between upper and lower casing parts **941** and **942** and the five components (emitters and receivers) mounted inside the device on a PCB (**943** in **FIG. 16**) connected to the lower casing part. An outer cross-shaped surface of lens **303** is flush with the outer casing.

[0071] **FIG. 15** is a cross-sectional view of the system shown in **FIG. 14**. Lens **303** is shown divided into sections to illustrate how each section is used by a different component. Detector **222.1** receives light beams that enter the lens through section **303.1**; emitter **122** uses section **303.2** to reflect light out of the lens; detector **222.2** receives light beams that enter the lens through section **303.3**.

[0072] **FIG. 16** is an exploded view of the system shown in **FIG. 15**. **FIG. 16** shows detectors **222.1 – 222.4** and emitter **122**; PCB **943**; upper and lower casing parts **941** and **942**; and lens **303** divided into upper section **303.1**, middle section **303.2** and lower section **303.3**.

[0073] **FIG. 17** is a slightly rotated side view of the system of **FIG. 16**. **FIG. 17** illustrates how middle section **303.2** of the lens is used by detectors **222.2** and **222.4** in addition to emitter **122**. An air gap **945** behind lens **303** is also shown. The purpose of air gap **945** is to make the diagonal face **320** of lens **303** internally reflective.

[0074] Reference is made to **FIGS. 18** and **19**, which are simplified illustrations of top-shooting diodes in a configuration of a touch sensitive window featuring four emitter-detector channels operative to detect a glide movement in both horizontal and vertical directions, in accordance with an embodiment of the present invention. **FIGS. 18** and **19** illustrate a mouse pad or other two-dimensional control. This configuration places the emitters and detectors directly beneath the control surface. **FIG. 18** shows four receivers **222.1** – **222.4** surrounding an emitter **122** to provide four channels, substantially similar to those described hereinabove with reference to **FIGS. 14** - **17**. In **FIG. 19** an infrared light transmissive cover **950** with a cross shape **951** etched thereon is placed above the emitters and receivers. The cross shape indicates navigational paths to the user.

[0075] A system with four channels also provides information in three dimensions regarding a proximal object. For example, begin with the two channels of **FIG. 2** to provide height information. Add one channel to provide lateral information as in **FIG. 3**. Add one more channel to provide information in a second lateral dimension, also as in **FIG. 3**.

Applications

[0076] Aspects of the invention relate to providing a thin window spanning the height or thickness of a device, such as a mobile phone. A user interacts with the phone by performing finger gestures against this window and the proximity sensor detects the position or gesture of the finger. One usage is to replace physical buttons. In a basic case light from an LED is sent out of the device and reflected by the finger. The reflected light is detected by two PDs situated on either side of the LED and the position of the finger is interpolated from the signals. For

instance such an arrangement could replace the volume buttons on a mobile phone.

[0077] Reference is made to **FIGS. 20 – 22**, which are simplified diagrams of hovering gestures using the touch sensitive window of **FIGS. 4** and **5**, in accordance with an embodiment of the present invention. **FIG. 20** shows a user interacting with a control in accordance with an embodiment of the present invention. **FIG. 20A** shows a mobile phone or other electronic device **910** having a screen **909** and a control window **310**. A finger **903** interacts with this control by sliding along the control or by tapping the control. A gesture of sliding finger **903** along window **310** is indicated by arrow **957**.

[0078] **FIG. 20B** shows the same mobile phone or other electronic device **910** having a screen **909** and a control window **310**. Two fingers **904** and **905** interact with this control. As an example, the fingers may alternately approach window **310** and move away from window **310**. Thus, in a first position of the gesture, finger **904** is placed opposite and near window **310** and finger **905** is placed opposite and distal from window **310**. Next, finger **904** is moved opposite and near window **310** and finger **905** is placed opposite and distal from window **310**. This example gesture can be seen as two fingers "walking" towards the control. This gesture uses the proximity detection described hereinabove to detect the finger movement toward and away from the control window. Another two-finger gesture is a pinch gesture whereby two fingers are brought together along the length of the control window. A spread gesture or "un-pinch" gesture moves two fingers away from each other along the length of the control window.

[0079] **FIG. 21** illustrates another two-finger gesture on electronic device **910** having a screen **909** and a control window **310**. Two fingers **904** and **905** interact with this control according to arrows **954** and **955**.

The gesture begins with lowered finger **905** opposite a portion of window **310** and finger **904** raised above the window. Finger **904** is lowered as per arrow **954** while finger **905** is raised as per arrow **955**.

[0080] **FIG. 22** illustrates another two-finger gesture on electronic device **910** having a screen **909** and a control window **310**. Two fingers **904** and **905** interact with this control according to arrows **964** and **965**. The gesture begins with lowered finger **905** opposite a portion of window **310** and finger **904** raised above the window. Fingers **904** and **905** perform circular motions at different phases to mimic "running in place" as per arrows **964** and **965**.

Expanding the User Interface

[0081] Aspects of the subject invention relate to an expanded user interface whereby the user performs gestures beyond the physical extent of an electronic device. The device includes one or more arrays of proximity sensors along the outer edges of the device housing. This detector array detects user gestures performed outside the perimeter of the device.

[0082] Reference is made to **FIG. 23**, which is a simplified diagram of an electronic device with proximity sensors along all four device edges, in accordance with an embodiment of the present invention. **FIG. 23** shows an electronic device **910** with a screen **909**. Along all four outer edges of device **910** are outgoing arrows indicating emitter light beams **126**, and incoming arrows indicating receiver light beams **226**, associated with arrays of proximity sensors along the edges of device **910** as described hereinabove.

[0083] Reference is made to **FIG. 24**, which is a simplified illustration of a user interface for a music application, in accordance with an embodiment of the present invention. **FIG. 24** shows a music mixer or

DJ application. Screen **909** is a touch screen displaying an interactive graphic of a record turntable **906** that is spun by a user rubbing his fingers **902** on the graphic. The device is placed on a table or other flat surface. The user manipulates parameters of the music application, such as volume, tempo, bass, treble, by manipulating slider controls **907** and **908**. In order to move the slider bar within the control, the user performs a sliding gesture parallel to an edge of the device. This is illustrated by finger **902** touching the slider bar in control **908**. Although slider controls **907** and **908** are illustrated in **FIG. 24**, in certain embodiments of the invention these controls are not presented to the user outside the device. Rather, the user interface responds to sliding one or more fingers parallel to an edge as if an actual or virtual slider control were being manipulated. Each edge controls a different music application parameter.

[0084] Reference is made to **FIG. 25**, which is a simplified illustration of a user interface for a drum application, in accordance with an embodiment of the present invention. Screen **909** presents a drum set as seen from above, including various drums and cymbals **911** - **915**. The drum set graphic is larger than the screen such that only a portion of certain drums and cymbals are shown on the screen. However, by extending the circle of a partially viewable drum or cymbal, the user can imagine where it would extend outside the screen. When the user touches or taps a location outside the screen at which the extension of a drum or cymbal would be located, such as locations **916** – **918**, the device generates an appropriate drum or cymbal sound in response. In **FIG. 25**, finger **901** is about to touch an extension **917** of cymbal **915**. In certain embodiments the extension is not presented to the user outside the device. Rather, the user interface responds to finger taps at

locations around the device that correspond to where a drum or cymbal would logically be placed according to the drum set graphic.

[0085] Thus the drum set is arranged in a layout that is larger than the display, wherein at any given time a subset of the drum set graphic is presented on the display. In certain embodiments, the drum set graphic pans, relative to the display, to bring a subset of the drum set graphic into the display, and to move another subset of the drum set graphic out of the display. The logical locations outside the display of the various drums and cymbals moved out of the display are meaningful to the user interface: when the user touches or taps one of these locations the device generates a corresponding drum or cymbal sound in response. The user pans the drum set graphic to understand where various drums are logically located outside the screen. In certain embodiments, the user may also zoom the drum set graphic to understand where certain drums are located outside the displayed portion of the graphic. In this case, when the drum set graphic is zoomed out the entire graphic fits on the display. As the graphic is zoomed in, it increases in size to the point that portions of the graphic do not fit on the screen. However, during the zoom operation the user sees where these off screen portions are logically located so that he can touch those locations to elicit drum sounds from the device. In **FIG. 25**, finger **900** is touching the logical location of drum **911** which is completely outside the display.

[0086] Reference is made to **FIG. 26**, which is a flow chart of a method for providing a graphical user interface (GUI), in accordance with an embodiment of the present invention. The GUI is described with reference to steps **1001** – **1007**. At step **1001** a graphic file is read. The graphic file is either one graphic or a composite graphic made up of various graphic elements from one or more files, e.g., graphics of various drums that together form a drum set. At step **1002** a portion of the

graphic is rendered on the screen, while the remainder of the graphic is mapped outside the screen. This may be because the graphic is too large to fit on the screen, or because it is situated near an edge of the screen. Alternatively some of the graphic elements are dynamic, and move and drift off the screen. Therefore, there are portions of the graphic elements that are not displayed, and these portions are mapped to locations outside the device at step **1003**. At step **1004** touch sensors on the screen detect a touch. At step **1005** proximity sensors around the device edges detect an object outside the device. Both detections are used by the user interface. In some instances only one detection occurs. In other instances multiple detections occur concurrently, e.g., multi-touch gestures are detected on the screen or multiple objects are detected at various locations around the device. The user interface maps each detected location or gesture to a corresponding graphic element at step **1006**. And at step **1007** the device generates user interface outputs that correspond to the detected touch or proximity locations or gestures.

[0087] Reference is made to **FIG. 27**, which is a simplified illustration of a user interface for a shooter game, in accordance with an embodiment of the present invention. A user interface for controlling a shooter game **920** involves finger gestures along different sides of the device. A player moves within the game's virtual world by finger movements along the bottom edge of the device. **FIG. 27** shows left and right arrows indicating sweep gestures by fingers **902** that move the player within the game's virtual world. The user aims his gun by performing gestures near the right edge of the device as indicated by sight **925**. The proximity sensors detect the movement of finger **901** in two or three dimensions enabling two-dimensional or three-dimensional manipulation of the gun. The user selects a different weapon by tapping at locations along the

device's left edge. **FIG. 27** shows guns **928** – **930** along this edge. A tap at each location selects the corresponding weapon.

[0088] Reference is made to **FIG. 28**, which is a simplified illustration of a user interface for a car racing game, in accordance with an embodiment of the present invention. **FIG. 28** shows a car racing game **933** in which a player steers a car through a race course. The player steers the car by gliding his fingers **901** and **902** along a circular path surrounding the device. The circular path has the shape of an imaginary steering wheel surrounding the device, as illustrated by steering wheel **934**. Gliding fingers clockwise along this circular path steers the car to the right, and gliding fingers counterclockwise along this path steers the car to the left – as if the gliding fingers are rotating a steering wheel.

[0089] Reference is made to **FIG. 29**, which is a simplified illustration of a user interface for a music player application, in accordance with an embodiment of the present invention. **FIG. 29** shows an MP3 player **936** in a stereo dock **937** being controlled by user interface gestures in the form of a hand **938** waving above and across the front of the device as indicated by arrow **939**. In this case, in order that the proximity sensor arrays around the edges of the device detect a hand above the device, the proximity sensor light beams are directed upward, perpendicular to the front of the device.

[0090] In this regard, reference is made to **FIG. 30**, which is a simplified diagram of an electronic device with proximity sensors along all four device edges, in accordance with an embodiment of the present invention. **FIG. 30** shows device **910** with screen **909** and emitter light beams **127** directed upward along the edges of the device. Hover detection occurs when an object reflects these upward beams back onto the proximity sensor receivers. Thus, emitter beams **127** become downward receiver beams **227** after being reflected by a hovering object.

[0091] Reference is made to **FIG. 31**, which is a simplified illustration of a user interface "bounce" gesture performed on device **910**, in accordance with an embodiment of the present invention. As shown in **FIG. 31**, a user bounces his hand **938** down and up above a screen, without touching the screen, as represented by a two-sided arrow **494**. Proximity detection beams **127** – **227** are used to recognize this bounce gesture as a series of increases in light reflected by hand **938** as it approaches the screen, followed by a series of decreases in light reflected by hand **938** as it moves away from the screen. In one embodiment of the present invention, the bounce gesture is used to activate a selected graphical user interface control.

[0092] Reference is made to **FIG. 32**, which is a simplified illustration of a user interface for an alarm clock application, in accordance with an embodiment of the present invention. **FIG. 32** shows an alarm clock application on a mobile phone device **910**. The user waves a hand **938** above and across the screen as illustrated by arrow **939** to turn off the alarm. In this case, too, the proximity sensors along the edges of the device are configured to project beams upward, perpendicular to screen **909**.

[0093] Reference is made to **FIG. 33**, which is a simplified illustration of a user interface for a camera application, in accordance with an embodiment of the present invention. **FIG. 33** shows a camera application on a mobile phone device **910** that is controlled by tap gestures and slide gestures along the outer edges of the phone. To take a picture, a user taps finger **901** at the upper right corner of the device as indicated by arrow **946**. Other parameters are configured or set by slide gestures along the top and bottom edges of device **910**, e.g., sliding finger **900** as indicated by arrow **947**, and sliding finger **903** as indicated by arrow **948**.

Protective Cover with Embedded Sensors

[0094] Aspects of the subject invention relate to a removable protective cover for an electronic device, such as a cell phone, an e-book reader, a music player and a tablet computer, that includes proximity sensors for detecting user gestures performed on an outside surface of the cover, and user gestures performed in the air in the vicinity of the cover. Such user gestures include contact gestures such as slides and taps as shown in **FIGS. 6** and **33**; and non-contact gestures in the air such as those shown in **FIGS. 20** - **32**. Thus it will be appreciated by those skilled in the art that the cover enhances the electronic device to be operable to respond to such user gestures. In an embodiment of the present invention, the cover includes a processor for controlling operation of the proximity sensors. In an embodiment of the present invention, the cover includes wireless communication circuitry, such as BLUETOOTH® circuitry, for transmitting information about user gestures that are detected by the proximity sensors in the cover, under control of the processor, to the electronic device; in response to which the electronic device processes commands based on the user gestures. Such commands include inter alia answer/reject incoming call commands, page turn commands for e0books, volume control commands, and play commands for music.

[0095] The cover may be made of a silicone-based material. The cover may also include a small battery.

[0096] Reference is made to **FIG. 34**, which is a simplified illustration of a removable cover **970** attached to a handheld electronic device **910**, in accordance with an embodiment of the present invention. As seen in **FIG. 34**, cover **970** at least partially covers rear and side surfaces of electronic device **910**. In one embodiment of the present invention, electronic device **910** is a cellphone. In another embodiment of the

present invention, electronic device **910** is a music player. In yet another embodiment of the present invention, electronic device **910** is a tablet computer.

[0097] A touch slider **980**, shown in **FIG. 34** along the left side edge of cover **970**, is operable to detect finger glider gestures and/or tap gestures. The length of touch slider **980** is indicated by element **981**. Touch slider **980** comprises a narrow slit through which light is transmitted out of cover **970** and reflected back into cover **970**. A second touch slider (element **982** of **FIG. 35**) may be provided along the right side edge of cover **970**. In operation, a user slides a finger along slider **980** in one direction to answer an incoming call, and slides the finger along slider **980** in the opposite direction to reject the incoming call. In one embodiment of the present invention, slider **980** is similar to the sliders shown in **FIGS. 4 – 6**.

[0098] Reference is made to **FIG. 35**, which is an exploded view of cover **970**, in accordance with an embodiment of the present invention. The rear portion of cover **970** is a slim housing formed by a front housing panel **972** and a rear housing panel **973**. Front and rear housing panels **972** and **973** encase (i) a printed circuit board (PCB) **976** on which wireless communication circuitry, light emitters and light receivers are mounted, and (ii) series of lenses **978**, **979** that direct light from the emitters outward. Touch slider **980** is formed by a narrow slit along a lower edge of cover **970**. Lenses **978** are exposed through this opening, and direct light from the emitters outward through touch slider **980**. When a user places a finger on slider **980**, the finger reflects the outward-directed light back through lens **978** onto one or more of the light receivers. A similar touch slider **982** is formed along the right side edge of cover **970** through a narrow slit that exposes lenses **979**.

[0099] PCB **976** incudes wireless communication circuitry for communication with device **910**. PCB **976** also includes a processor configured to operate the light emitters and light receivers, and to operate the wireless communication circuitry to transmit commands to device **910** based on gestures detected when the light receivers sense an increase in reflected light. A battery **974** powers the electrical components used by cover **970**. Battery **974** is housed in rear housing panel **973**.

[00100] Reference is made to **FIG. 36**, which is an assembled view of cover **970**, in accordance with an embodiment of the present invention. As shown in **FIG. 36**, touch slider **980** exposes lenses **978**.

[00101] Reference is made to **FIG. 37**, which is a top perspective view of cover **970** with front housing panel **972** removed, in accordance with an embodiment of the present invention. **FIG. 37** shows an arrangement of a row of alternating light emitters **121** and light receivers **221**, and another row of alternating light emitters **122** and light receivers **222**. Series **978** of lenses is aligned with the row of alternating emitters and receivers **121** – **221**, and series **979** of lenses is aligned with the row of alternating emitters and receivers **122** – **222**.

[00102] **FIG. 37** also shows three emitters **123** – **125** of visible light, where each emitter emits light of a different color, e.g., red, green and blue. The visible colored light emitted by these emitters is transmitted through one of the series of lenses, e.g., lens series **979**, thereby coloring the entire proximity sensor strip. Representative applications for coloring the proximity sensor strip are described below with reference to **FIG. 39**.

[00103] **FIG. 37** also shows an emitter and receiver driver circuit **985**, which is operable to drive the emitters and to receive outputs from the receivers. Such a circuit is described in assignee's co-pending patent

application US Serial No. 13/424,413 entitled ASIC CONTROLER FOR LIGHT-BASED TOUCH SCREEN, the contents of which are hereby incorporated by reference in their entirety. A CPU **986** controls driver circuit **985**, and includes an embedded core for a wireless communication protocol, such as BLUETOOTH®.

[00104] Reference is made to **FIG. 38**, which is a bottom perspective transparent view of cover **970**, in accordance with an embodiment of the present invention. **FIG. 38** shows the arrangement of PCB **976**, lens series **978** and **979**, and rows of alternating emitters **121**, **122** and light receivers **221**, **222** inside the rear portion of cover **970**. **FIG. 38** also shows the right-side slider **982** which exposes lens series **979** along the right side edge of cover **970**.

[00105] A power socket **990** for charging battery **974** is provided by socket holes in the rear surface of casing **970**. In addition, two on/off button controls **992** and **993** are provided, exposed on the rear surface of cover **970**. Button **992** toggles the proximity sensors on and off. Button **993** toggles detectability of the proximity sensor system to external BLUETOOTH® devices, such as the covered phone.

[00106] Reference is made to **FIG. 39**, which is a schematic layout of PCB **976**, in accordance with an embodiment of the present invention. Emitters **121** and **122**, and receivers **221** and **222** in the two rows of alternating emitters and receivers generally operate in the near infrared spectrum, at wavelengths of approximately 930 nm. Lens series **978** and **979**, shown in **FIGS. 35**, **37** and **38**, are transparent to this wavelength, but may be opaque for light in the visible range.

[00107] In some embodiments of the present invention, lens series **978** and **979** are transparent for light in the visible range, in order to provide visual cues to a user. **FIG. 39** shows three emitters **123** – **125** of visible light, where each emitter emits light of a different color, e.g., red, green

and blue. Visible colored light from these emitters travels through one of the lens series, e.g., lens series **979**, coloring the proximity sensor strip. E.g., when a user charges battery **974** by inserting connector prongs into socket **990**, the proximity sensor strip turns red. When battery **974** is fully charged, the proximity sensor strip changes from red to blue. When the proximity sensors are detectable to external BLUETOOTH® devices, such as the covered phone, the proximity sensor strip changes to green. When detactability is turned off, the strip light is turned off.

[00108] **FIGS. 39** also shows an antenna **987** used by the embedded BLUETOOTH® core in CPU **986**, for wireless communication with the covered phone.

[00109] Whereas cover **970** illustrated in **FIGS. 34 – 38** includes one-dimensional sliders along edges of the cover, other embodiments are also within the scope of the present invention. Such embodiments include inter alia all of the arrangements of proximity sensors described hereinabove, but having some or all of the proximity sensors mounted in cover **970** instead of in device **910**; e.g., proximity sensors arranged in two dimensions on the rear of cover **970**, as described hereinabove with reference to **FIGS. 18** and **19**, and proximity sensors arranged around all four sides of cover **970**, as described hereinabove with reference to **FIGS. 23** and **30**. Thus it will be appreciate by those skilled in the art that cover **970** may be used in conjunction with device **910** to enable the various applications (music, drums, games, alarm clock, camera) described hereinabove with reference to **FIGS. 24**, **25**, **27 – 29**, **32** and **33**, and the method described hereinabove with reference to **FIG. 26**.

[00110] In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be

made to the specific exemplary embodiments without departing from the broader spirit and scope of the invention as set forth in the appended claims. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

1. An electronic device, comprising:

a housing;

a display mounted in said housing;

a plurality of proximity sensors mounted in said housing near the edges of said display and directed outward from said display, for detecting presence of an object outside said display and near the edges of said display; and

a processor mounted in said housing and coupled with said display and with said proximity sensors, for operating the device responsive to user activation of elements of a graphical user interface (GUI), the GUI comprising a displayed portion that is rendered by the processor on said display, and a virtual non-displayed portion that extends beyond the edges of said display,

wherein said processor operates the device responsive to user activation of elements of the virtual portion of the GUI, based on said proximity sensors detecting presence of an object in the non-displayed portion of the GUI.

2. The electronic device of claim **1** wherein the displayed portion of the GUI comprises a portion of a GUI element, and the virtual portion of the GUI comprises the remainder of the GUI element.

3. The electronic device of claim **1** wherein the virtual portion of the GUI comprises an entire GUI element.

4. The electronic device of claim **1** wherein said display comprises a touch screen.

5. The electronic device of claim **4** wherein said processor pans the GUI, to move at least one of the GUI elements from the virtual portion to the displayed portion, and to move at least one other of the GUI elements from the displayed portion to the virtual portion, responsive to user input from said touch screen.

6. The electronic device of claim **1** wherein the device comprises a music player, and wherein the GUI comprises musical elements, and wherein said processor causes the device to produce different sounds responsive to user activation of different musical elements.

7. A camera, comprising:

a housing;

a viewfinder mounted in said housing;

a plurality of proximity sensors mounted in said housing near the edges of said viewfinder and directed outward from said viewfinder, for detecting presence of a finger outside said viewfinder and near the edges of said viewfinder; and

a processor mounted in said housing and coupled with said viewfinder and with said proximity sensors,

wherein said processor causes the camera to capture a current frame in said viewfinder in response to a user tap at a first location on the outside of the edges of said viewfinder, based on said proximity sensors detecting presence of a finger at the first location.

8. The camera of claim **7**, wherein said processer causes the camera to adjust a first parameter of said viewfinder responsive to a user slide gesture at a second location on the outside of the edges of said viewfinder, based on said proximity sensors detecting presence of a finger at the second location.

9. The camera of claim **7**, wherein said processer causes the camera to adjust a second parameter of said viewfinder responsive to a user slide gesture at a third location on the outside of the edges of said viewfinder, based on said proximity sensors detecting presence of a finger at the third location.

10. An electronic device, comprising:

a housing;

a display mounted in said housing;

a plurality of proximity sensors mounted in said housing near the edges of said display and directed outward from said display, for detecting presence of an object outside said display and near the edges of said display; and

a processor mounted in said housing and coupled with said display and with said proximity sensors, for operating the device responsive to user activation of a virtual control located outside of the device,

wherein said processor operates the device responsive to user activation of the virtual control, based on said proximity sensors detecting presence of an object outside of the device.

11. The electronic device of claim **10**, wherein the device simulates a racing car game on said display, wherein said virtual control comprises

a virtual steering wheel virtually located on a circle surrounding the device, and wherein said processor steers a racing car responsive to user activation of said virtual steering wheel.

12. The electronic device of claim **10**, wherein said device simulates a shooting game on said display, wherein said virtual control comprises a virtual direction selector, and wherein said processor aims a weapon at a target rendered on said display responsive to user activation of said virtual direction selector.

13. The electronic device of claim **12**, further comprising a second virtual control located along the outside of an edge of the device, wherein said second virtual control comprises a virtual movement tracker, and wherein said processor moves a shooting avatar within said display responsive to user activation of said virtual movement tracker.

14. The electronic device of claim **13**, further comprising a third virtual control located along the outside of another edge of the device, wherein said third virtual control comprises a virtual weapon selector, and wherein said processor selects a shooting weapon responsive to user activation of said virtual weapon selector.

15. The electronic device of claim **10**, wherein the device is a music player, wherein said virtual control is a virtual slider for adjusting music parameters for a song currently being played by the device, wherein said display comprises a touch screen that renders a turntable control, and wherein said processor advances the current song responsive to glide gestures on the turntable control.

16. An electronic device, comprising:

a housing;

a display mounted in said housing;

a plurality of proximity sensors mounted in said housing near the edges of said display and directed upwards from said display, for detecting presence of an object above said display; and

a processor mounted in said housing and coupled with said display and to said proximity sensors,

wherein said processor operates the device responsive to a user wave gesture above said display, based on said proximity sensors detecting presence of an object above said display.

17. The electronic device of claim **16**, wherein the device comprises a music player, and wherein said processor advances a song currently being played by the music player responsive to the user wave gesture above the device.

18. The electronic device of claim **16**, wherein the device comprises an alarm clock, and wherein said processor turns off an alarm responsive to the user wave gesture above the device.

19. A removable cover for a handheld electronic device, comprising:

a protective cover that at least partially covers rear and side surfaces of a handheld electronic device;

a plurality of proximity sensors mounted in said cover for detecting user gestures performed outside of the electronic device;

a battery;

wireless communication circuitry; and

a processor configured to operate said proximity sensors, and to operate said wireless communication circuitry to transmit commands to the electronic device based on gestures detected by said proximity sensors.

20. The removable cover of claim **19** wherein the electronic device comprises a cell phone, and wherein the transmitted commands comprise commands to answer/reject an incoming call.

21. The removable cover of claim **20** wherein the transmitted commands comprise commands to control volume of sound produced by the electronic device.

22. The removable cover of claim **19** wherein the electronic device comprises a music player, and wherein the transmitted commands include play control commands.

23. The removable cover of claim **19** wherein said wireless communication circuitry comprises BLUETOOTH® communication circuitry.

24. The removable cover of claim **19** wherein the user gestures detected by said proximity sensors comprise slide and tap gestures along a surface of said cover.

25. The removable cover of claim **19** wherein the user gestures detected by said proximity sensors comprise non-contact gestures performed in the air, in the vicinity of said cover.

26. The removable cover of claim **19** wherein said proximity sensors comprise:

alternating light emitters and light receivers; and

lenses that direct light beams from said light emitters out of said protective cover through narrow slits in said protective cover,

wherein a finger that covers one or more of said lenses reflects the directed light beams back through the opening and, via said lenses, onto one or more of said light receivers.

27. The removable cover of claim **26** wherein said proximity sensors are arranged as a strip along a side of said cover.

28. The removable cover of claim **26** wherein said proximity sensors are arranged in two dimensions on the rear of said cover.

29. The removable cover of claim **28** wherein said processor transmits a first command to the electronic device based on a first slide gesture, detected by said proximity sensors, performed in a first direction on the rear side of said cover, and transmits a second command to the electronic device based on a second slide gesture, detected by said proximity sensors, performed in a second direction, substantially perpendicular to the first direction, on the rear side of said cover.

30. The removable cover of claim **28** wherein said processor transmits to the electronic device a command to control an application running on the electronic device, based on a wave gesture, detected by said proximity sensors, performed over the rear of said cover.

31. The removable cover of claim **26** wherein said lenses are positioned inside of said cover facing the narrow slits in said cover.

32. The removable cover of claim **31** wherein the electronic device comprises a cell phone, and wherein said processor transmits to the electronic device a command to answer an incoming phone call, based on a slide gesture along one of the narrow slits, detected by said proximity sensors.

33. The removable cover of claim **31** wherein the electronic device comprises a cell phone, and wherein said processor transmits to the electronic device a command to hang up a phone call, based on a slide gesture along one of the narrow slits, detected by said proximity sensors.

34. The removable cover of claim **31** wherein said processor transmits to the electronic device a command to modify volume of sound produced by the electronic device, based on a slide gesture along one of the narrow slits, detected by said proximity sensors.

35. The removable cover of claim **31** wherein the electronic device is a music player, and wherein said processor transmits a play control command to the electronic device, in response to a slide gesture along one of the narrow slits, detected by said proximity sensors.

36. The removable cover of claim **31** wherein the electronic device comprises a camera, and wherein said processor transmits a camera control command to the electronic device, based on a tap gesture on one of the narrow slits, detected by said proximity sensors.

37. The removable cover of claim **31** wherein said processor transmits a command to the electronic device to control an application running on the electronic device, based on a slide gesture performed at a distance away from one of the narrow slits, detected by said proximity sensors.

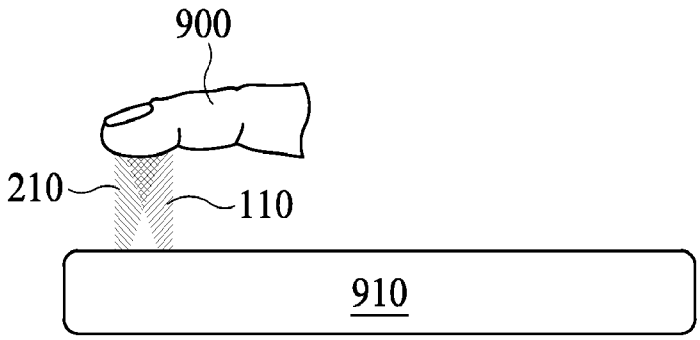


FIG. 1

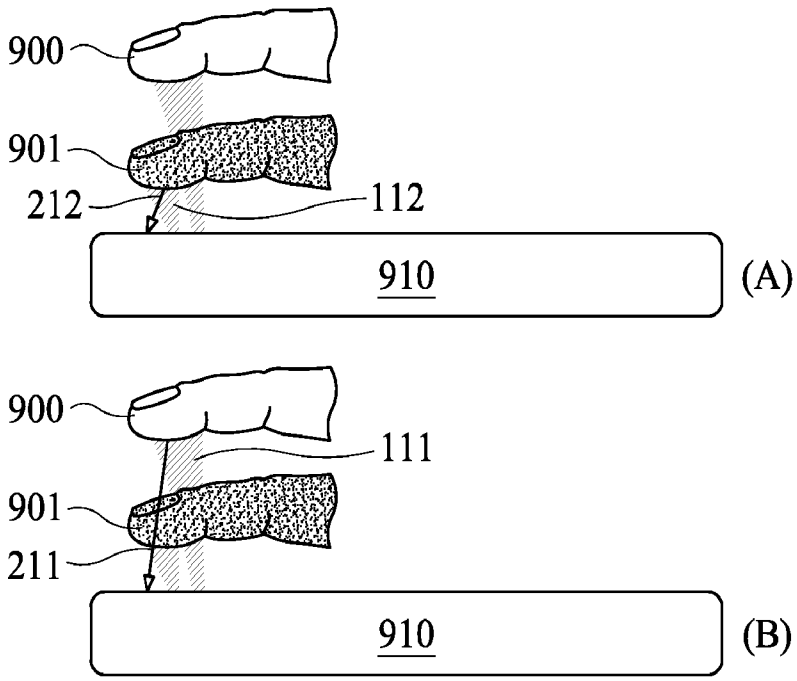


FIG. 2

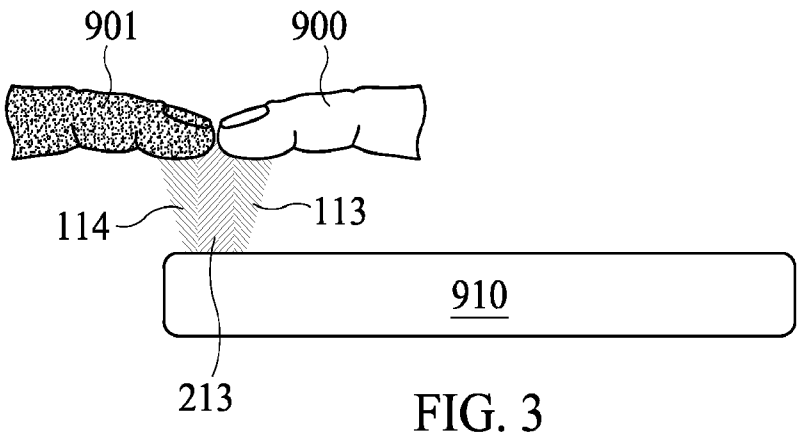


FIG. 3

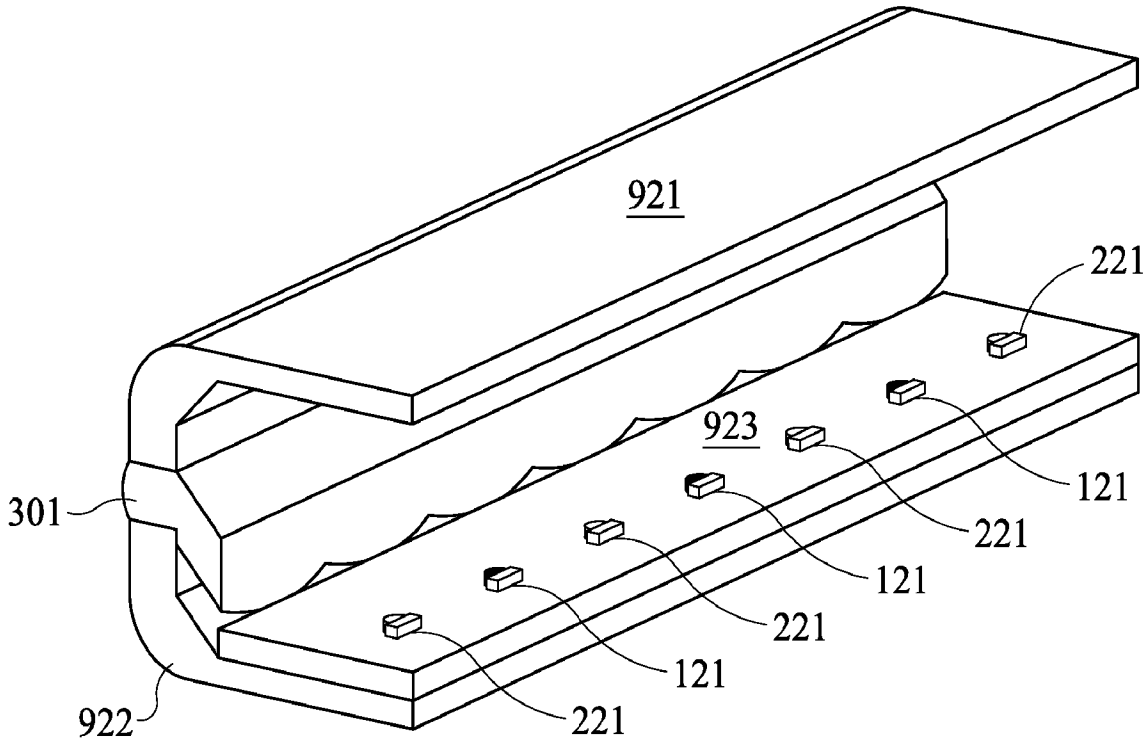


FIG. 4

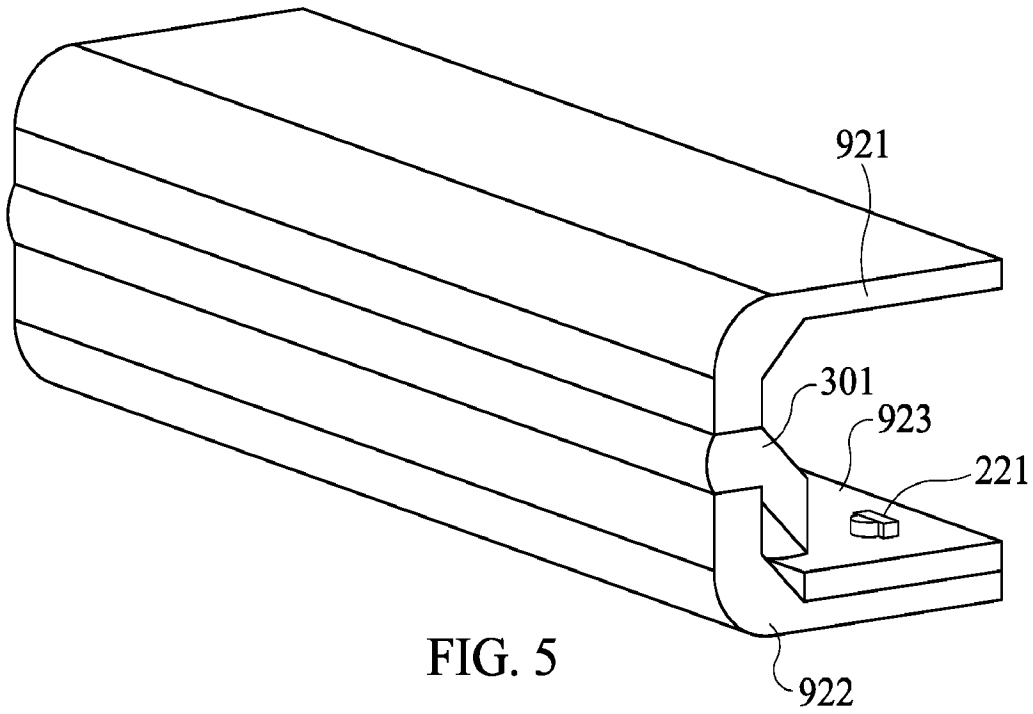


FIG. 5

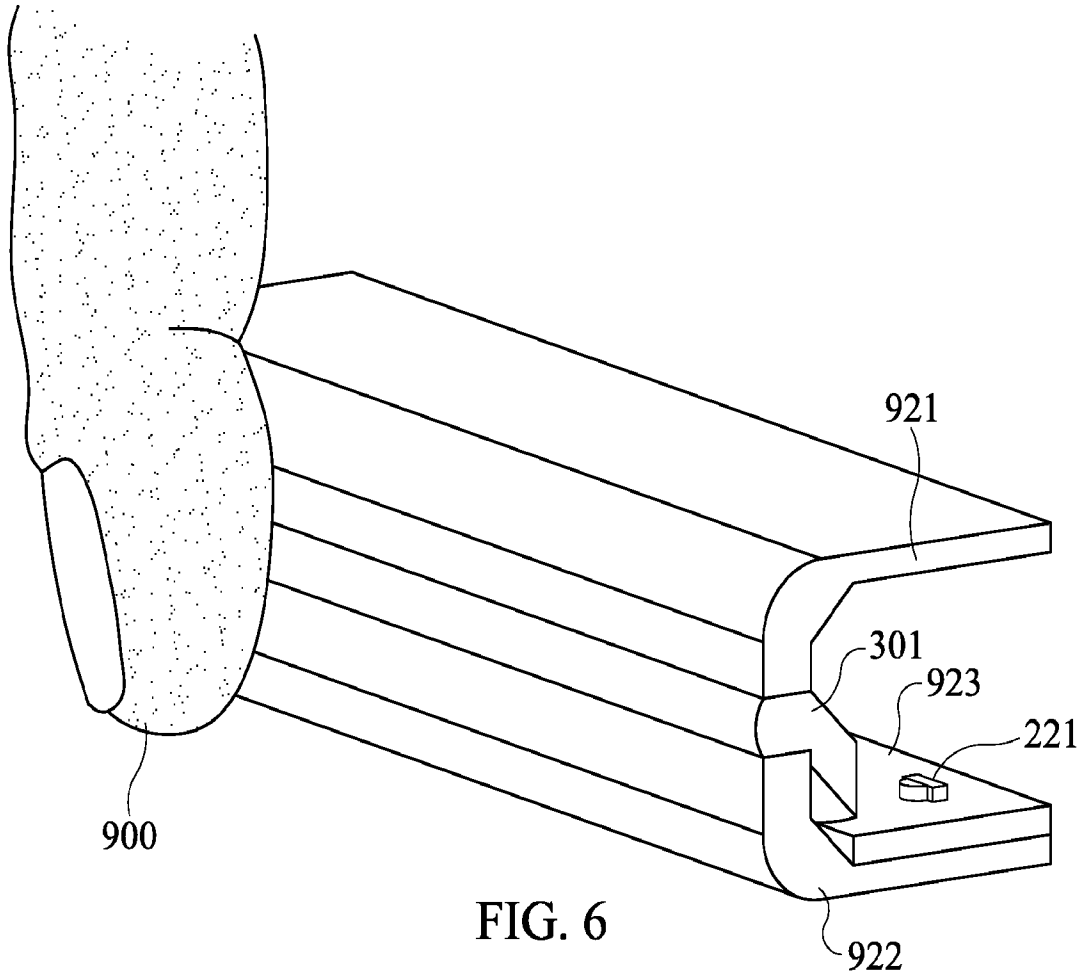


FIG. 6

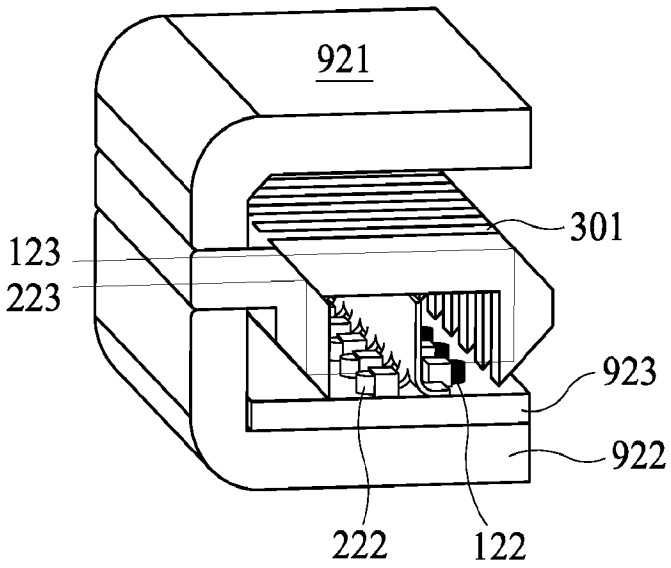


FIG. 7

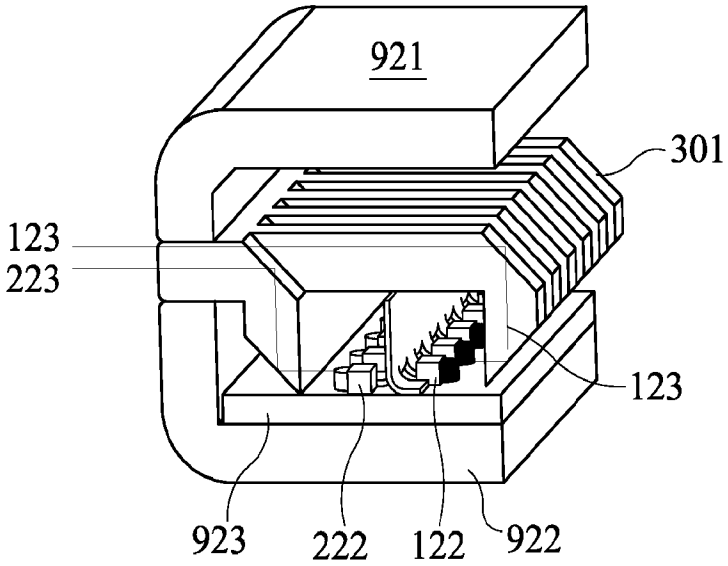

921
301
123
223
123
923
222
122
922

FIG. 8

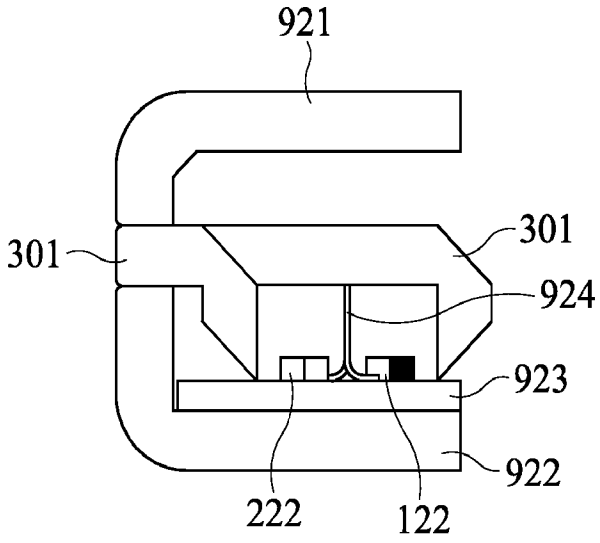

921
301
301
924
923
922
222
122

FIG. 10

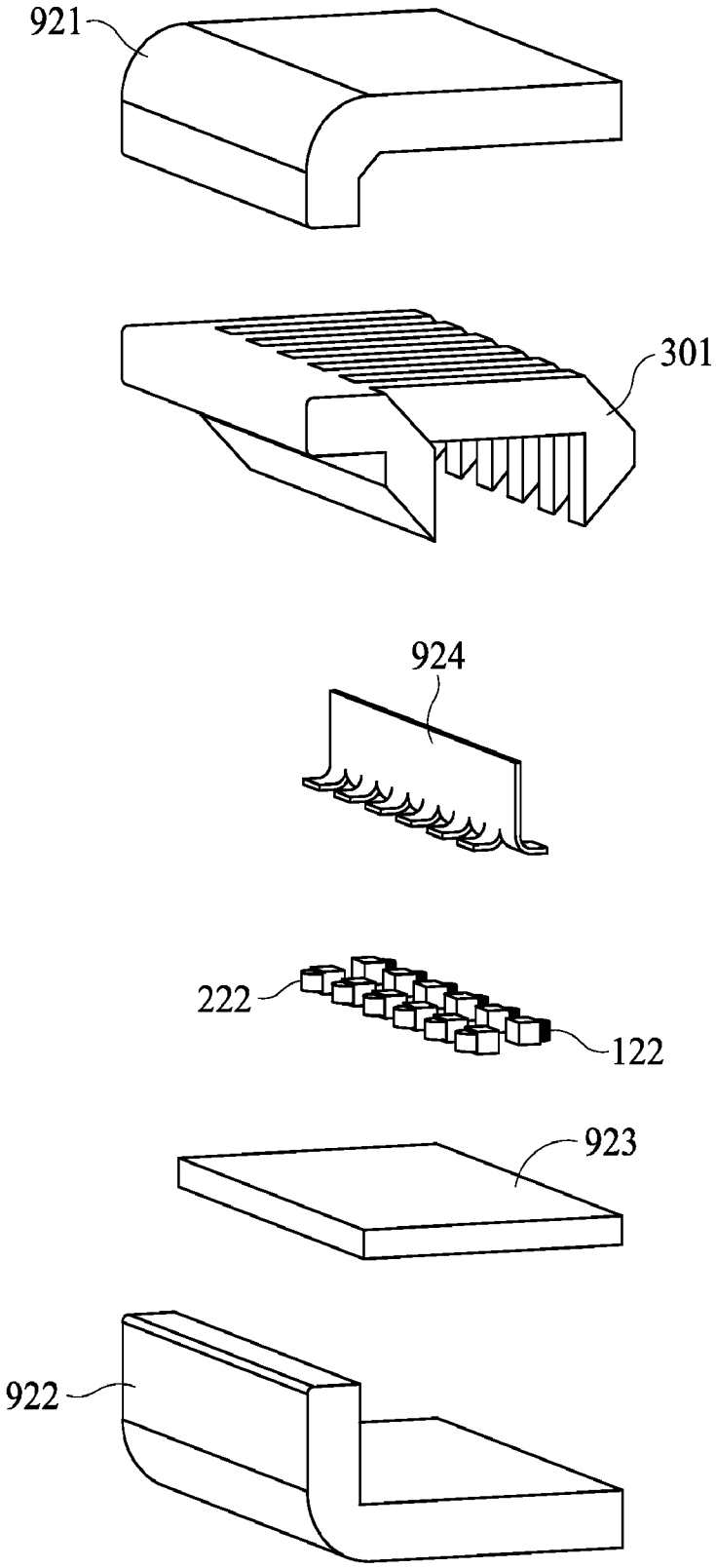


FIG. 9

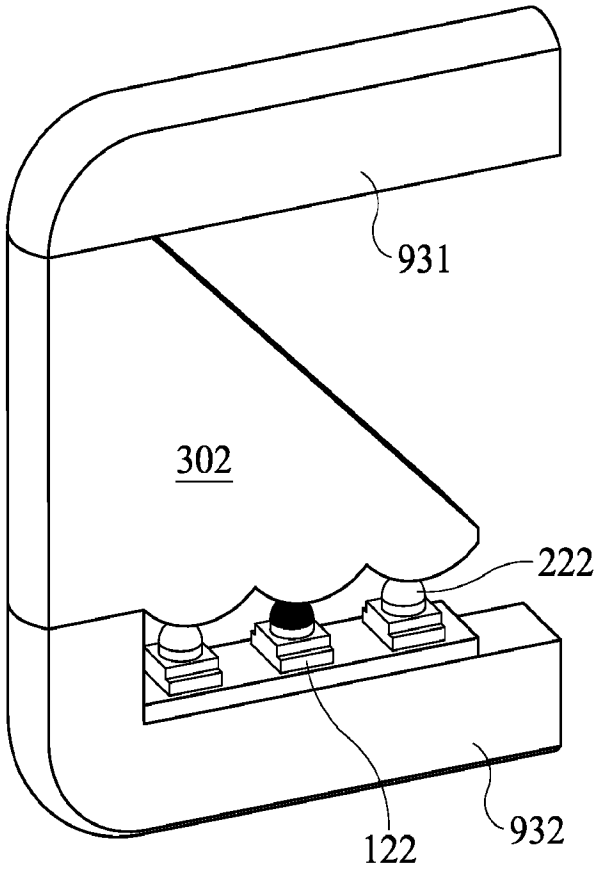


FIG. 11

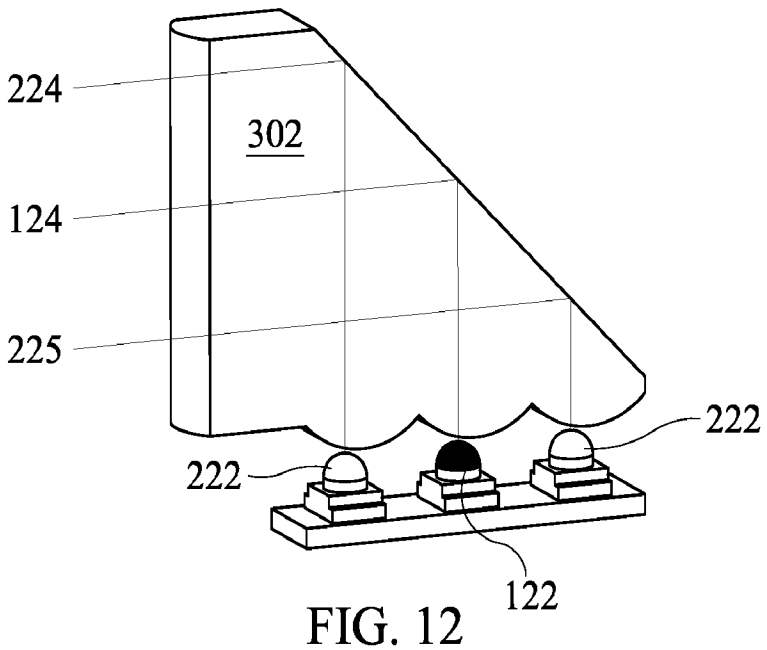


FIG. 12

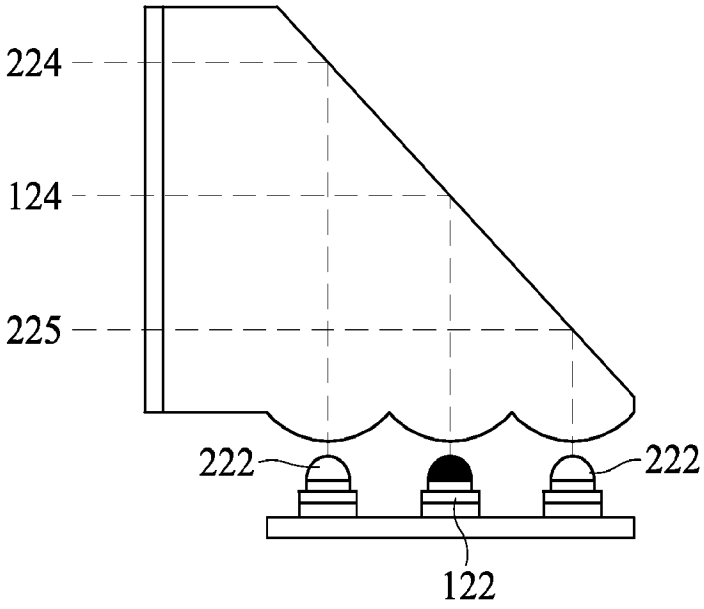


FIG. 13

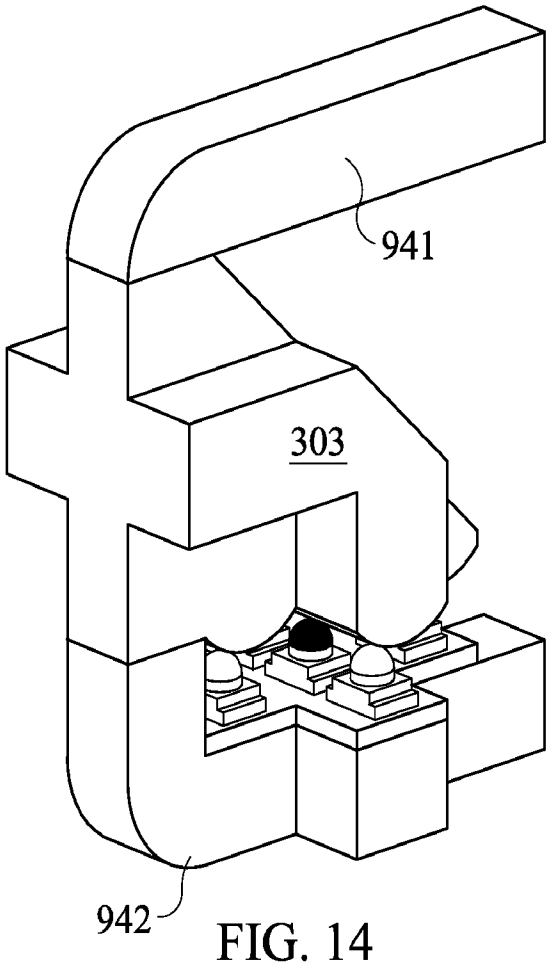


FIG. 14

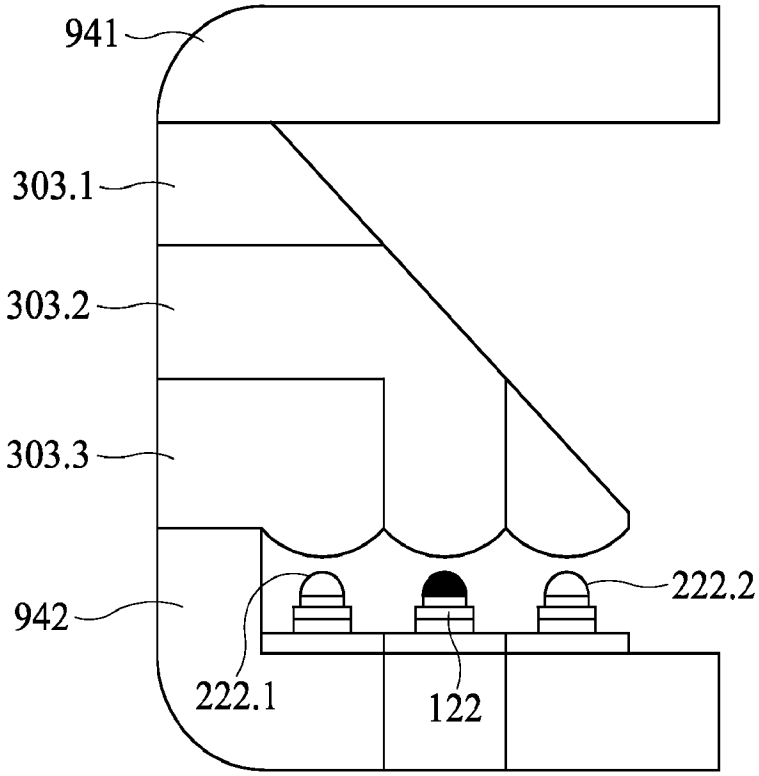

941
303.1
303.2
303.3
942
222.2
222.1
122

FIG. 15

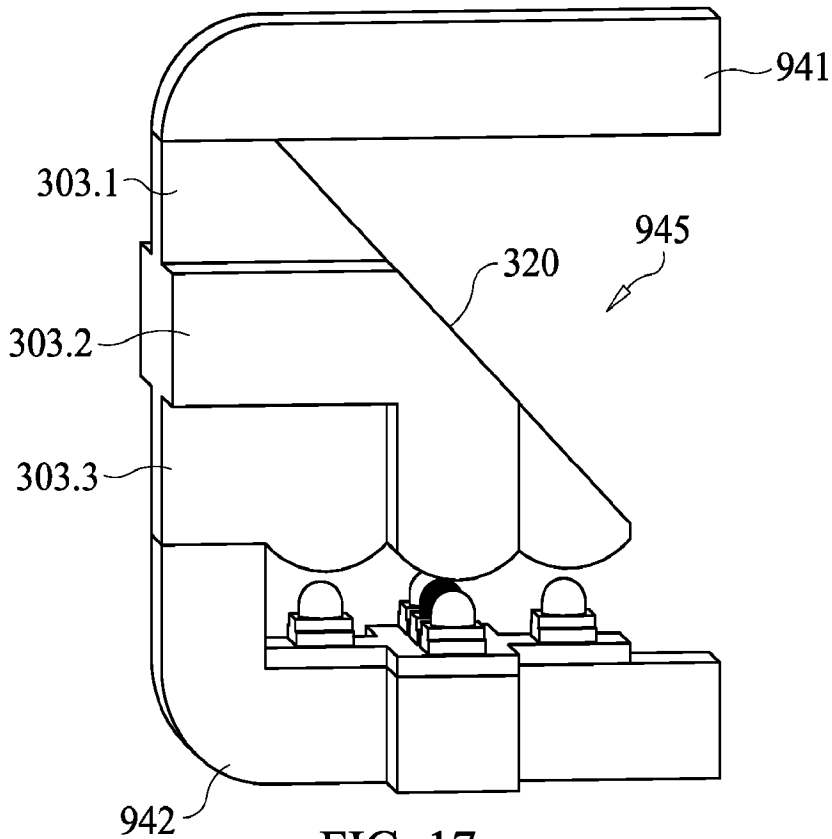

941
303.1
945
320
303.2
303.3
942

FIG. 17

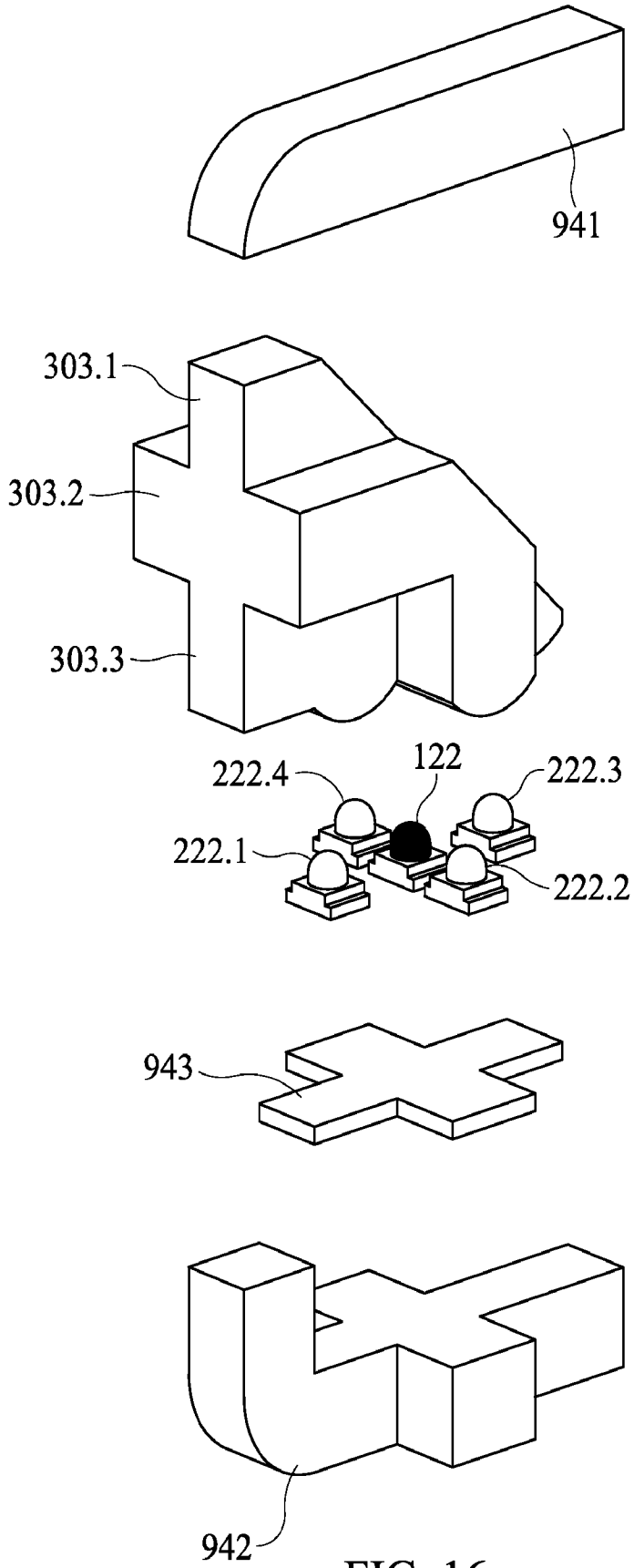


FIG. 16

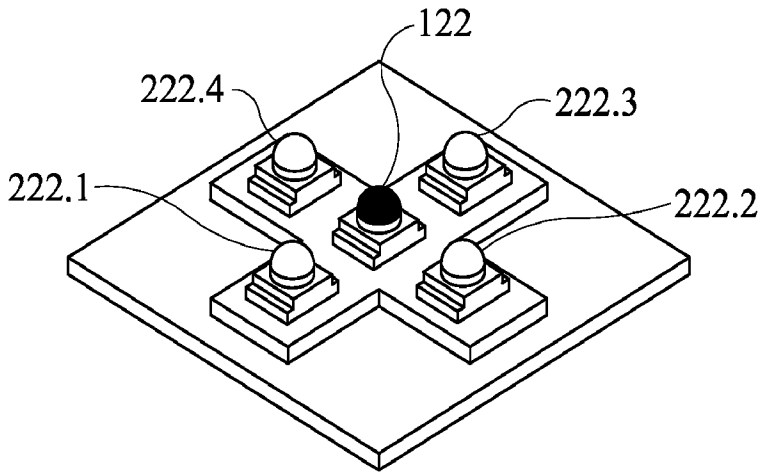


FIG. 18

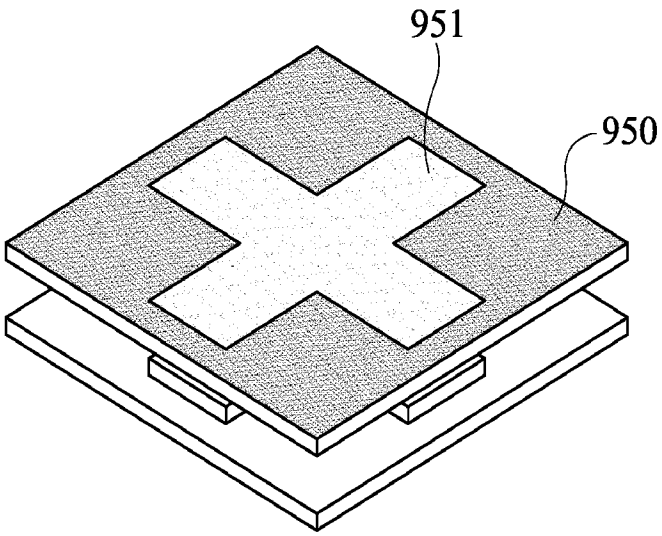


FIG. 19

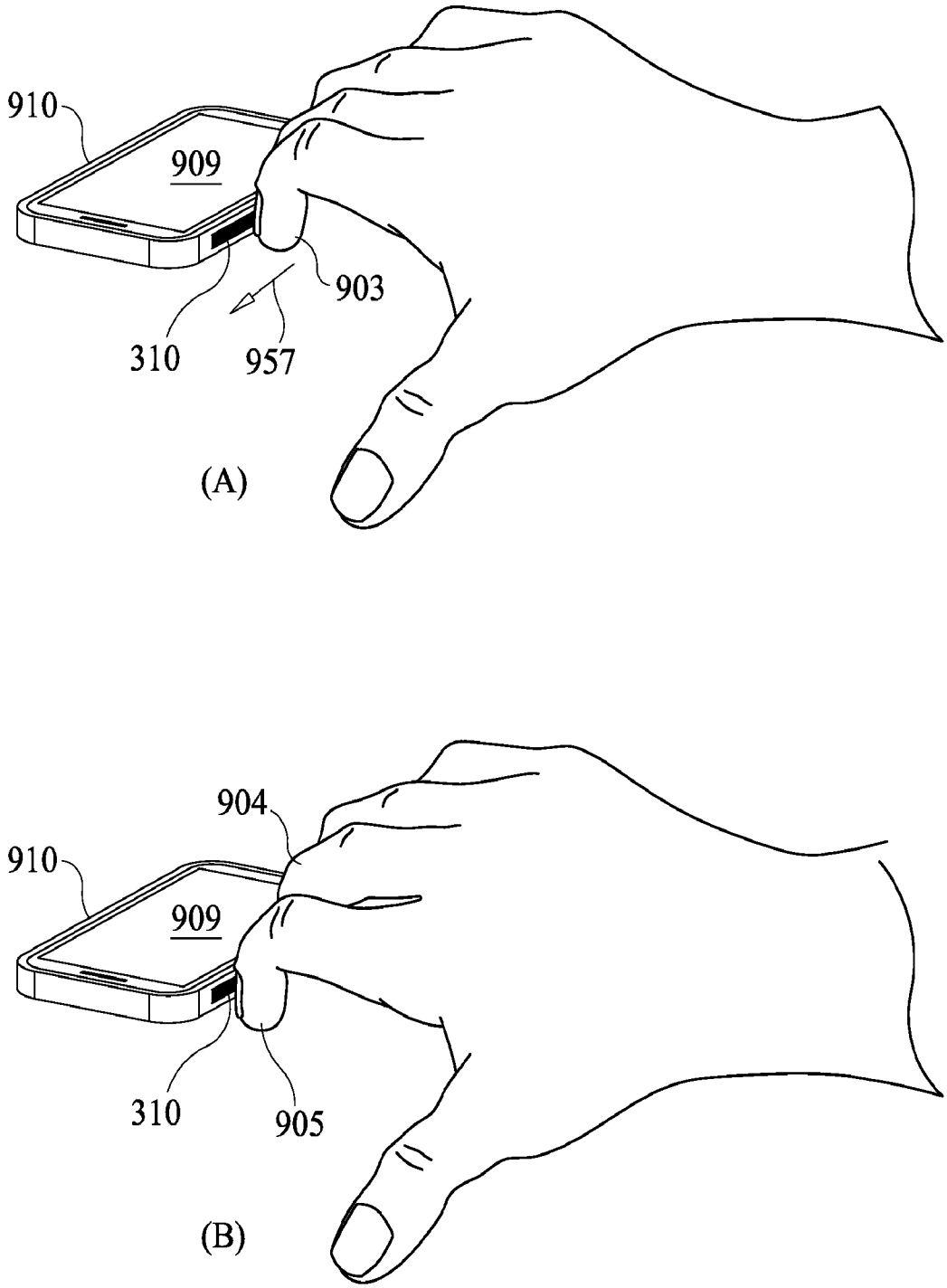


FIG. 20

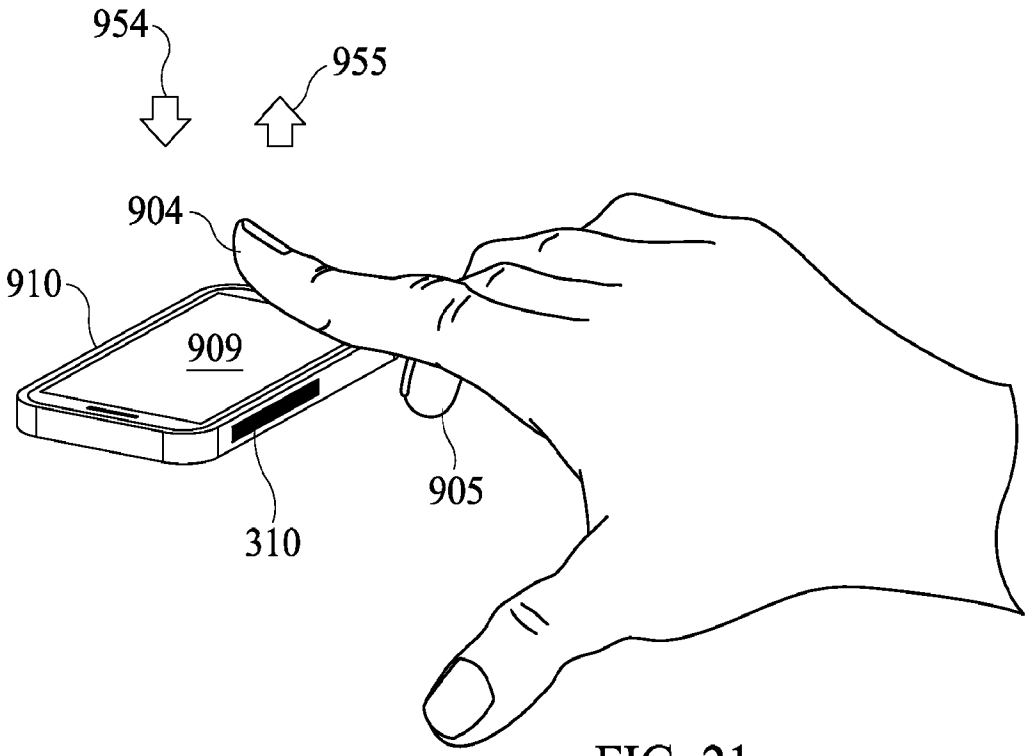


FIG. 21

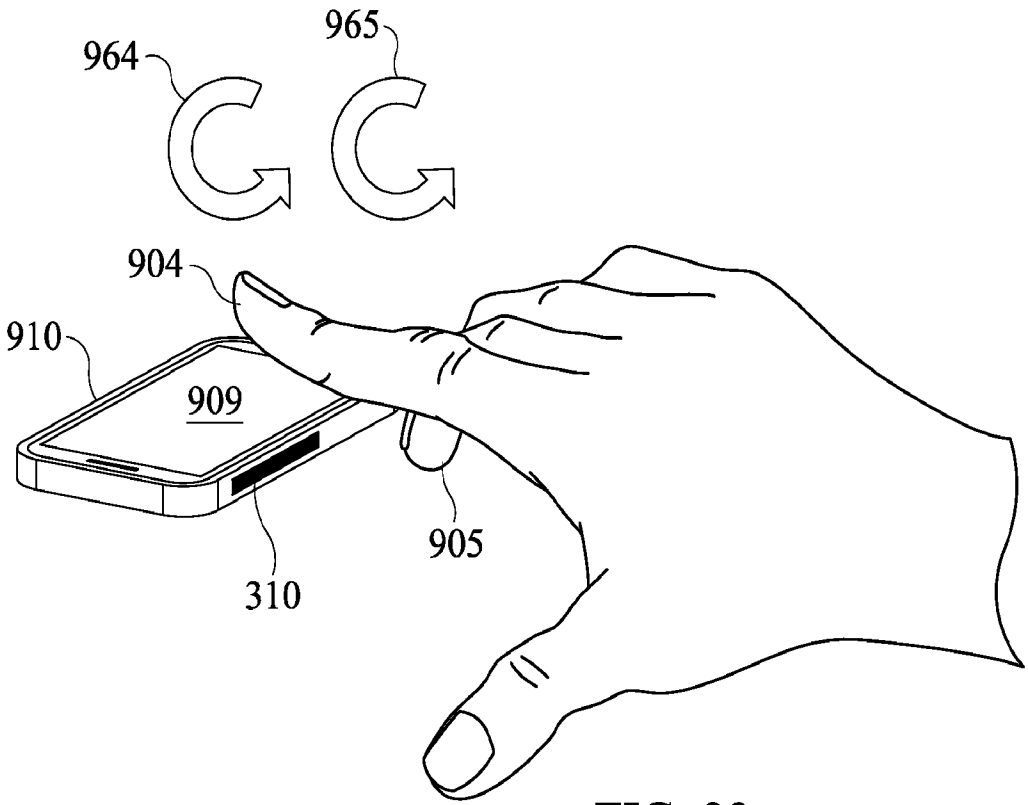


FIG. 22

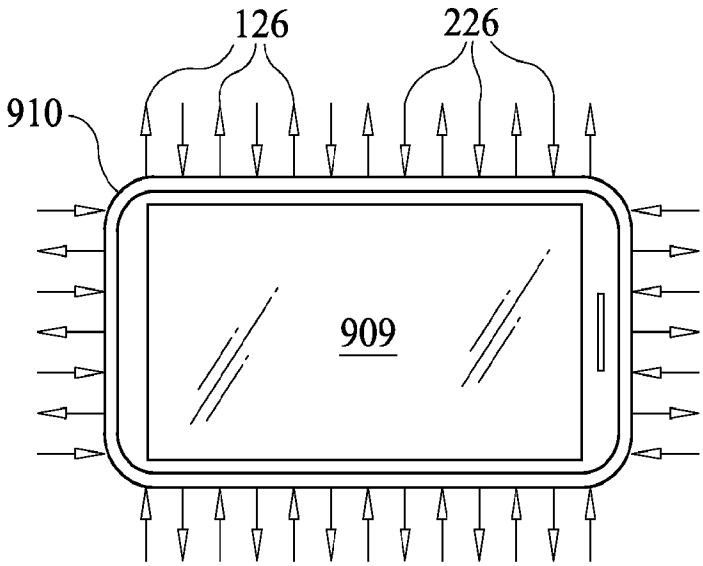


FIG. 23

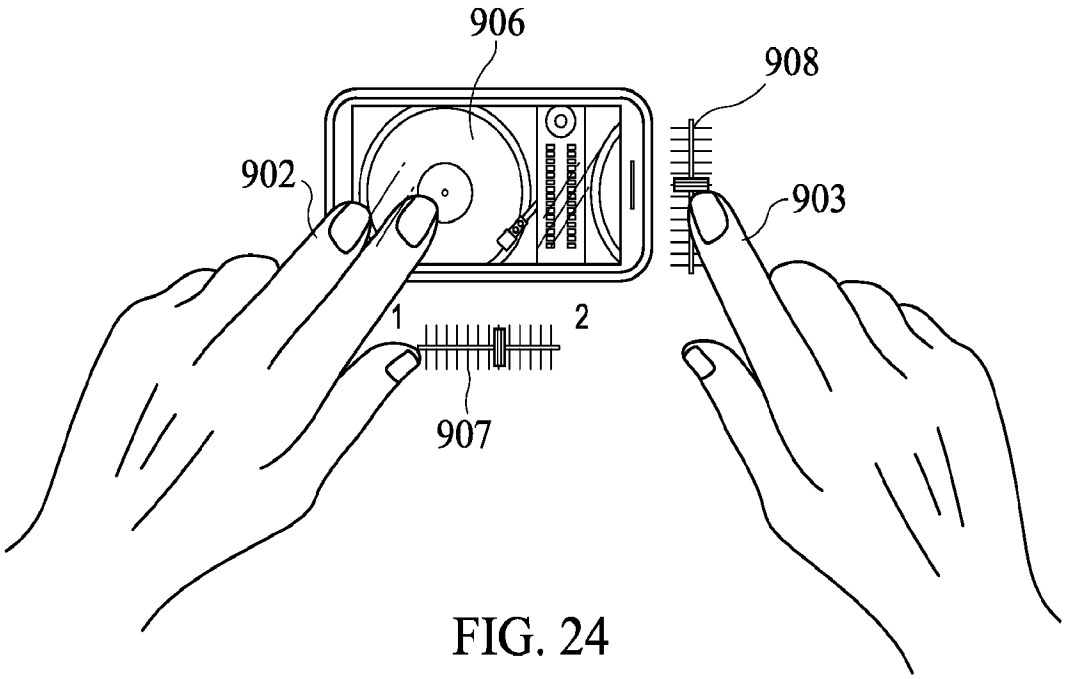


FIG. 24

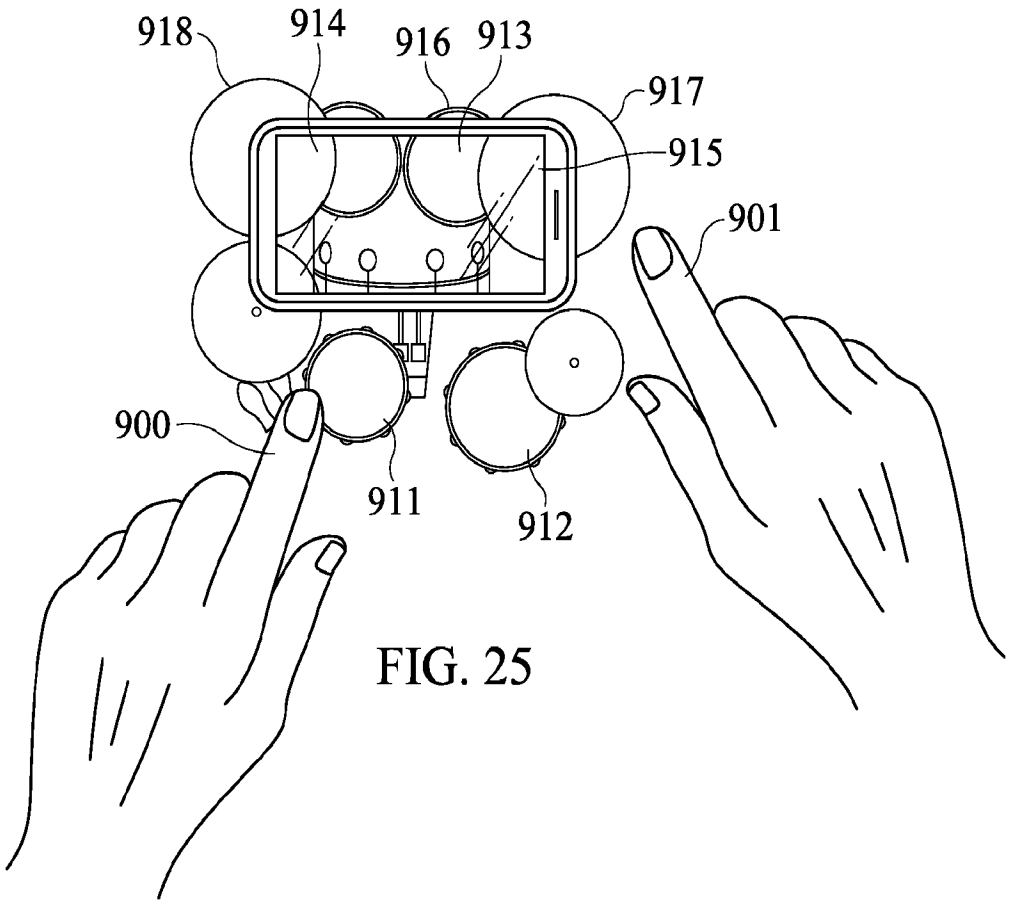


FIG. 25

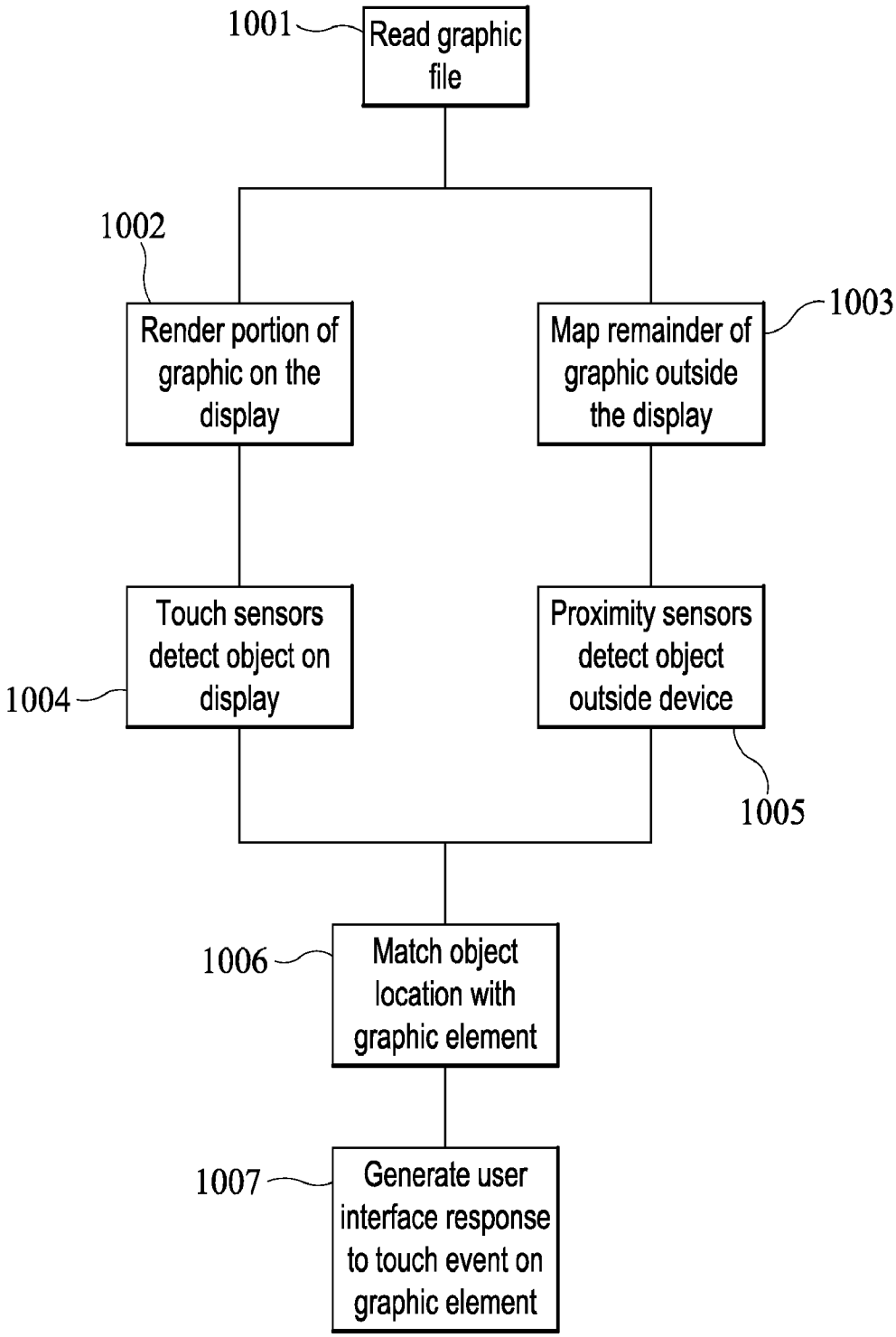

1001
Read graphic file
1002
Render portion of graphic on the display
1003
Map remainder of graphic outside the display
Touch sensors detect object on display
1004
Proximity sensors detect object outside device
1005
1006
Match object location with graphic element
1007
Generate user interface response to touch event on graphic element

FIG. 26

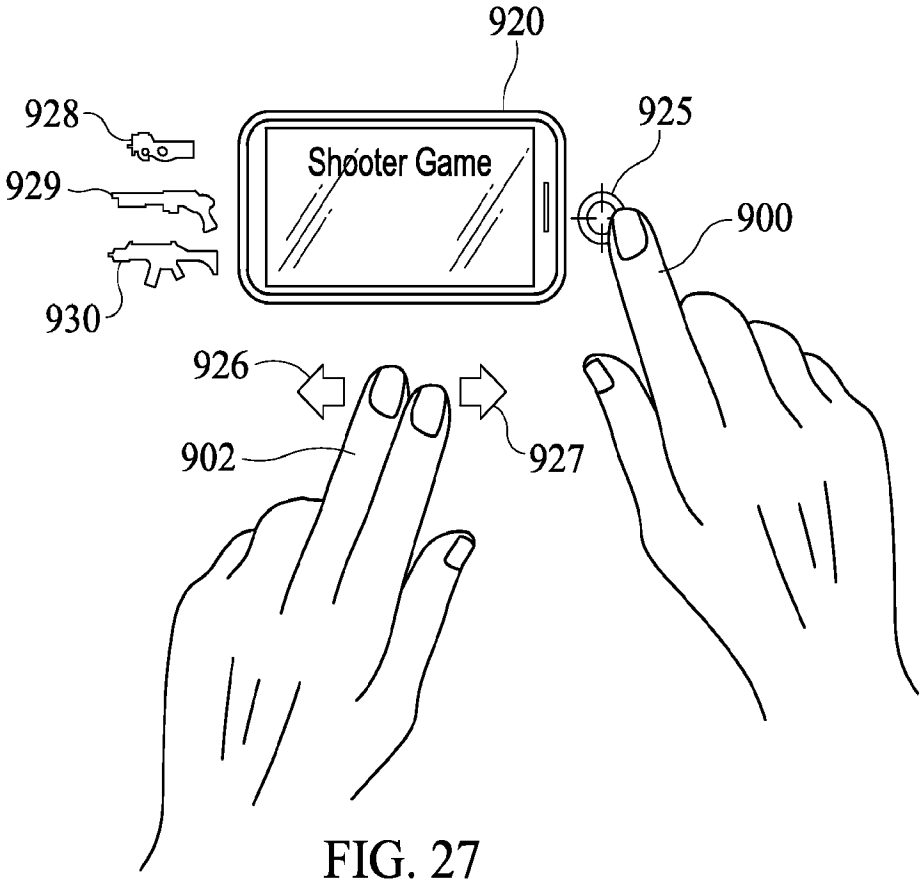

920
928
929
930
Shooter Game
925
900
926
902
927

FIG. 27

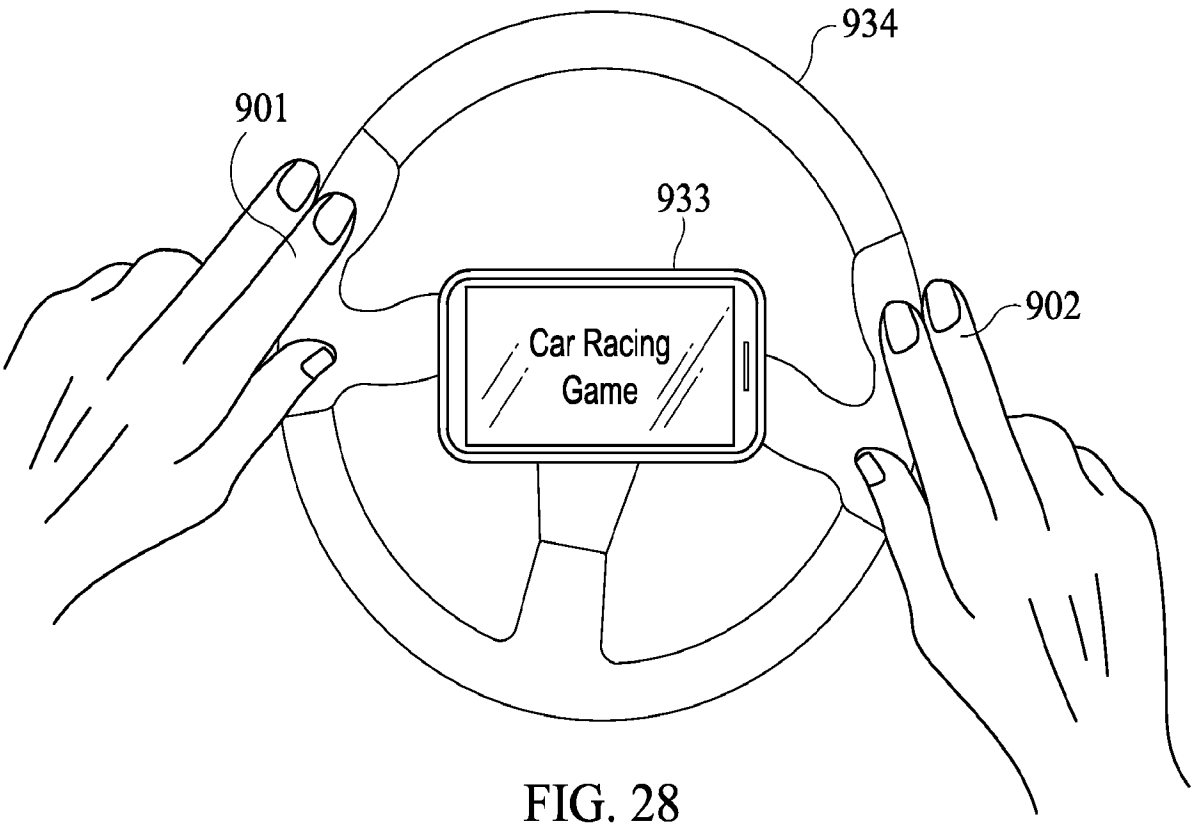

934
901
933
Car Racing Game
902

FIG. 28

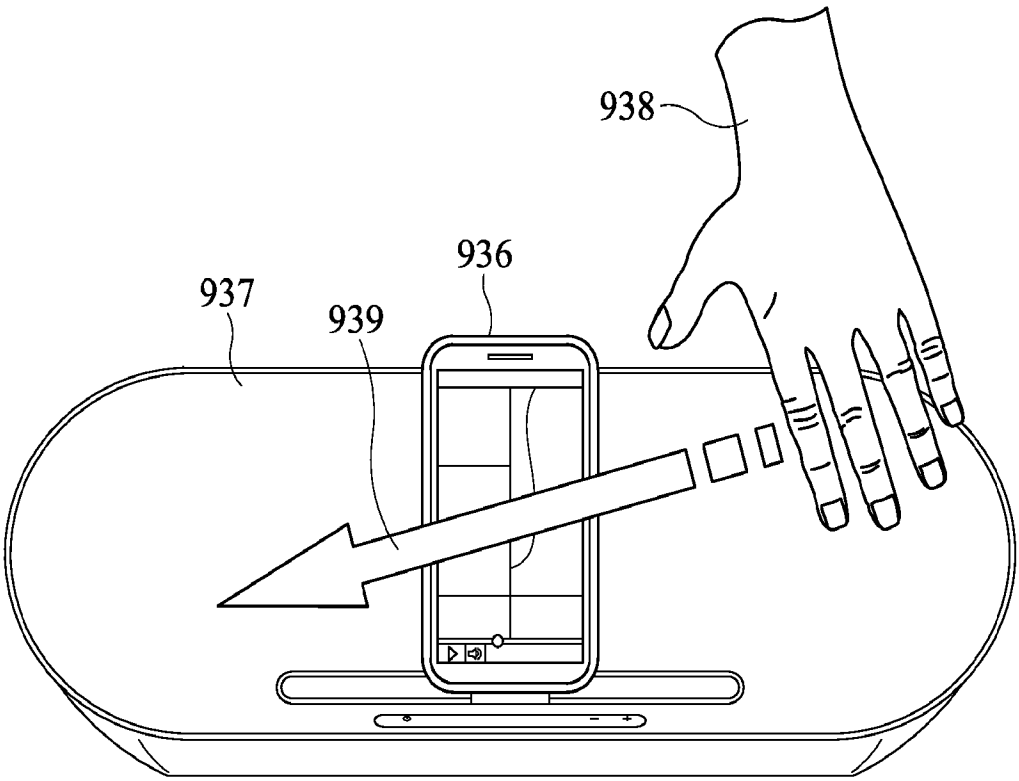


FIG. 29

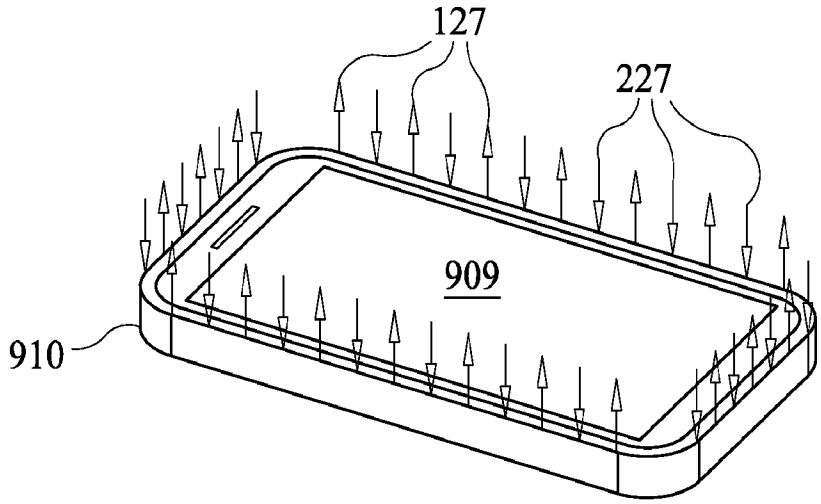


FIG. 30

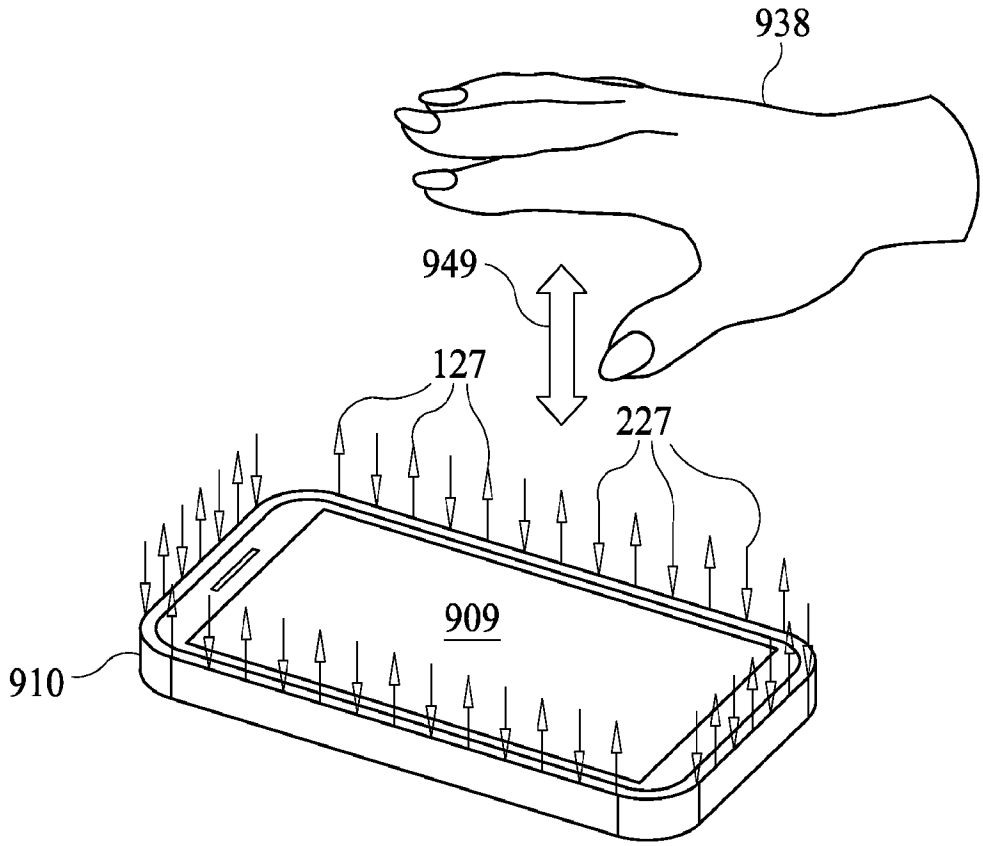


FIG. 31

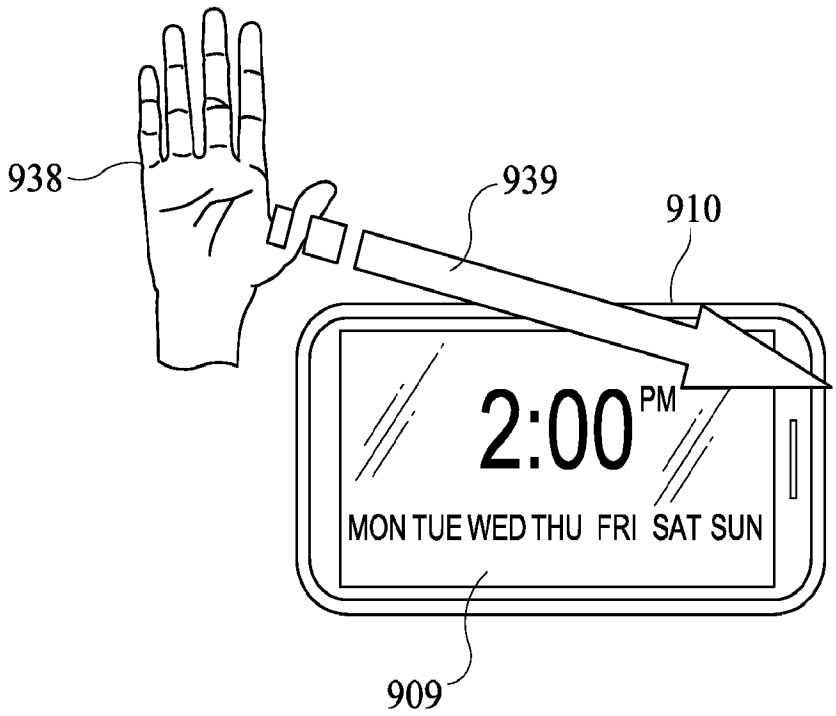

938
939
910
2:00 PM
MON TUE WED THU FRI SAT SUN
909

FIG. 32

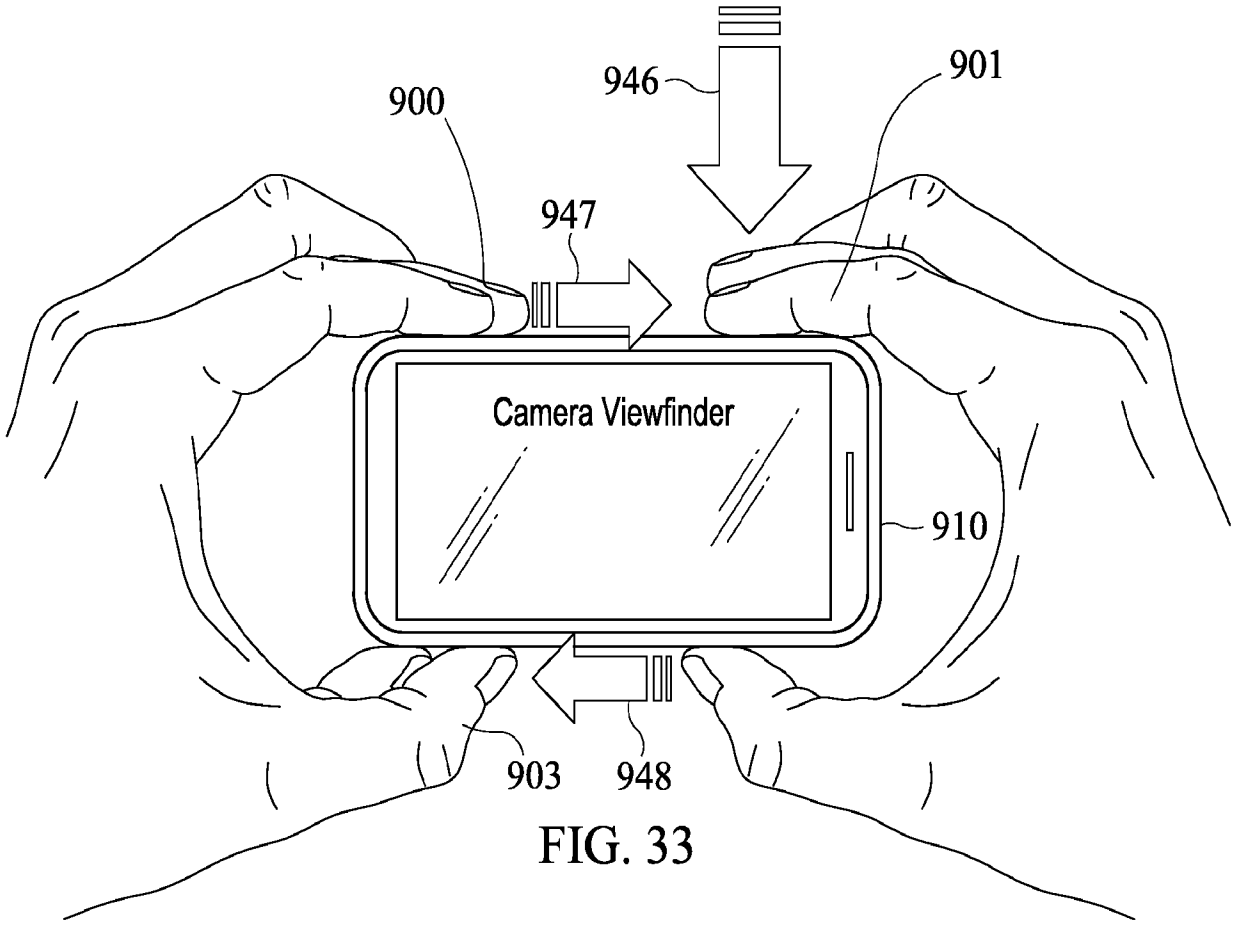

946
901
900
947
Camera Viewfinder
910
903
948

FIG. 33

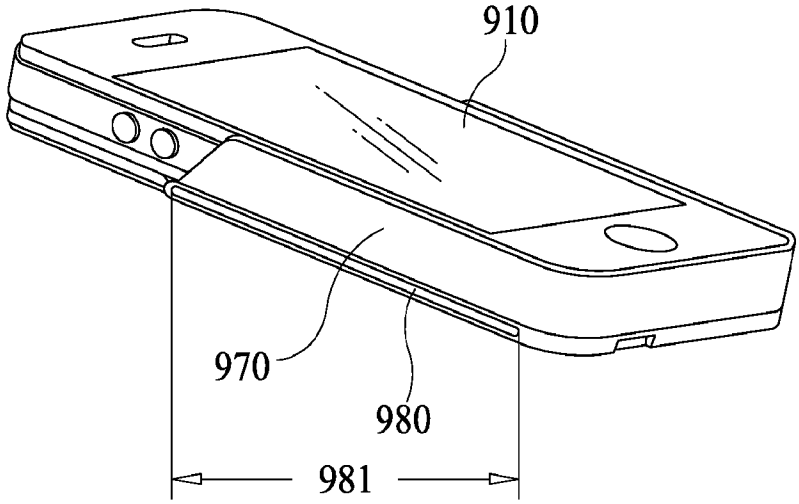


FIG. 34

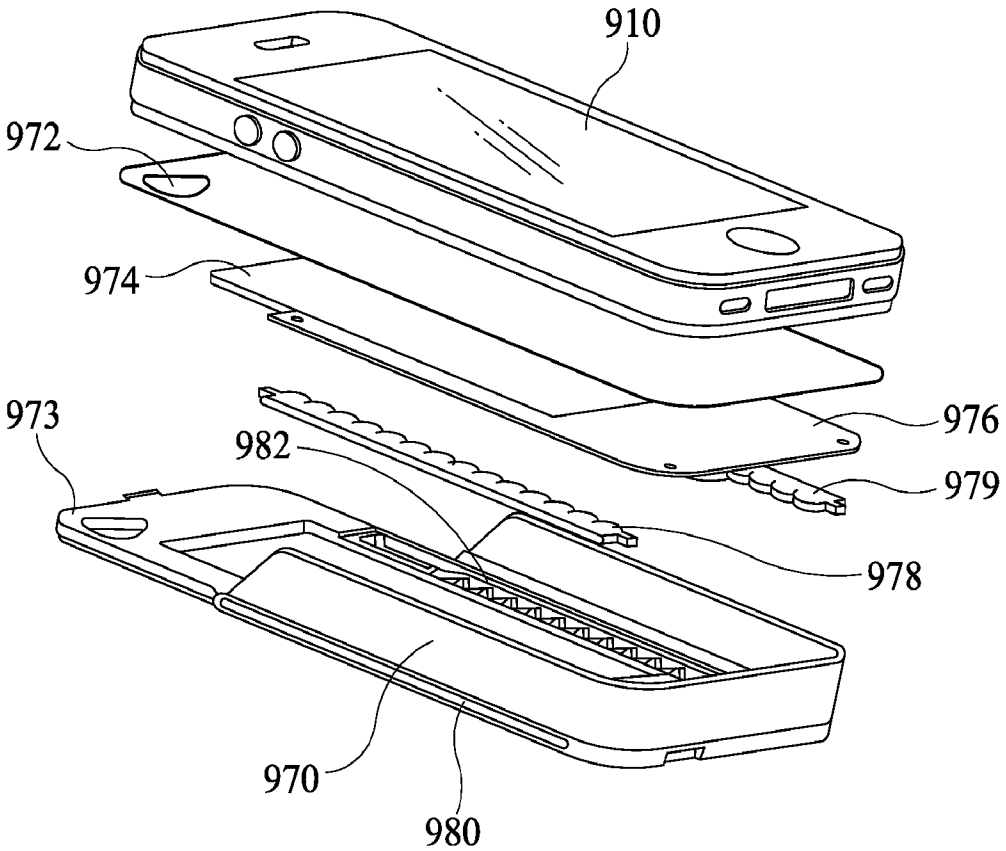


FIG. 35

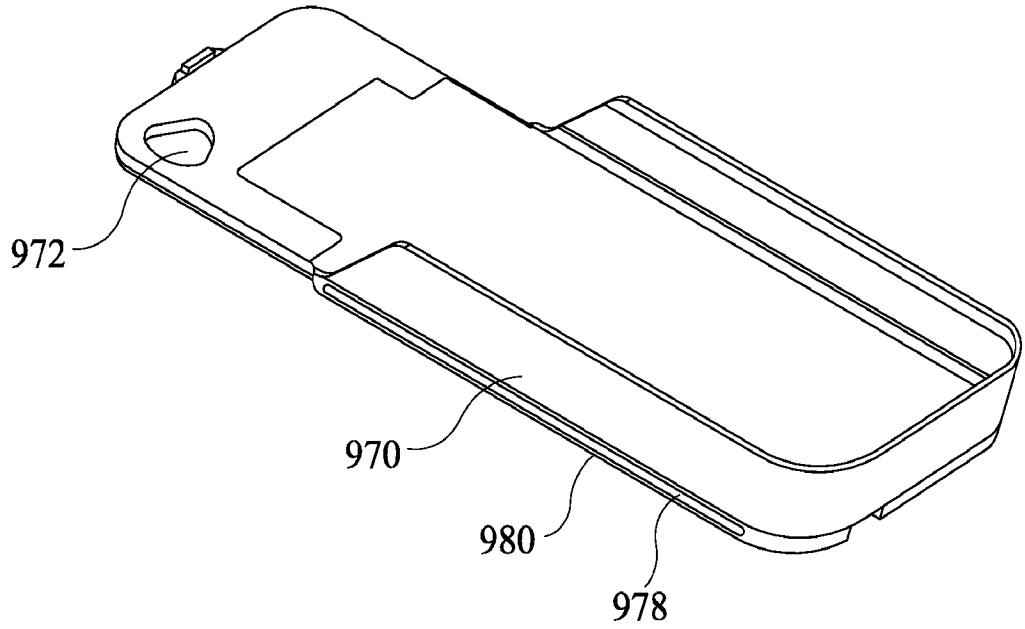

972
970
980
978

FIG. 36

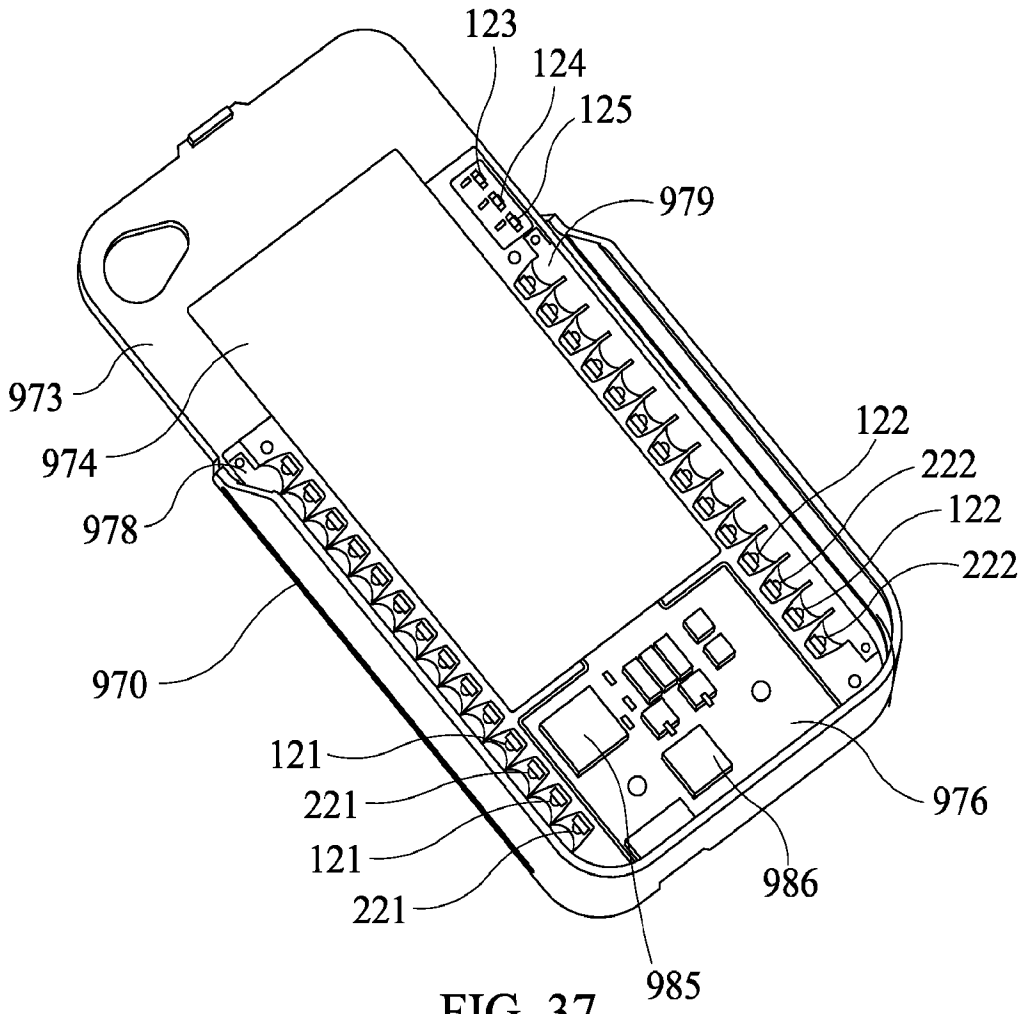

123
124
125
979
973
974
978
970
122
222
122
222
121
221
121
221
976
986
985

FIG. 37

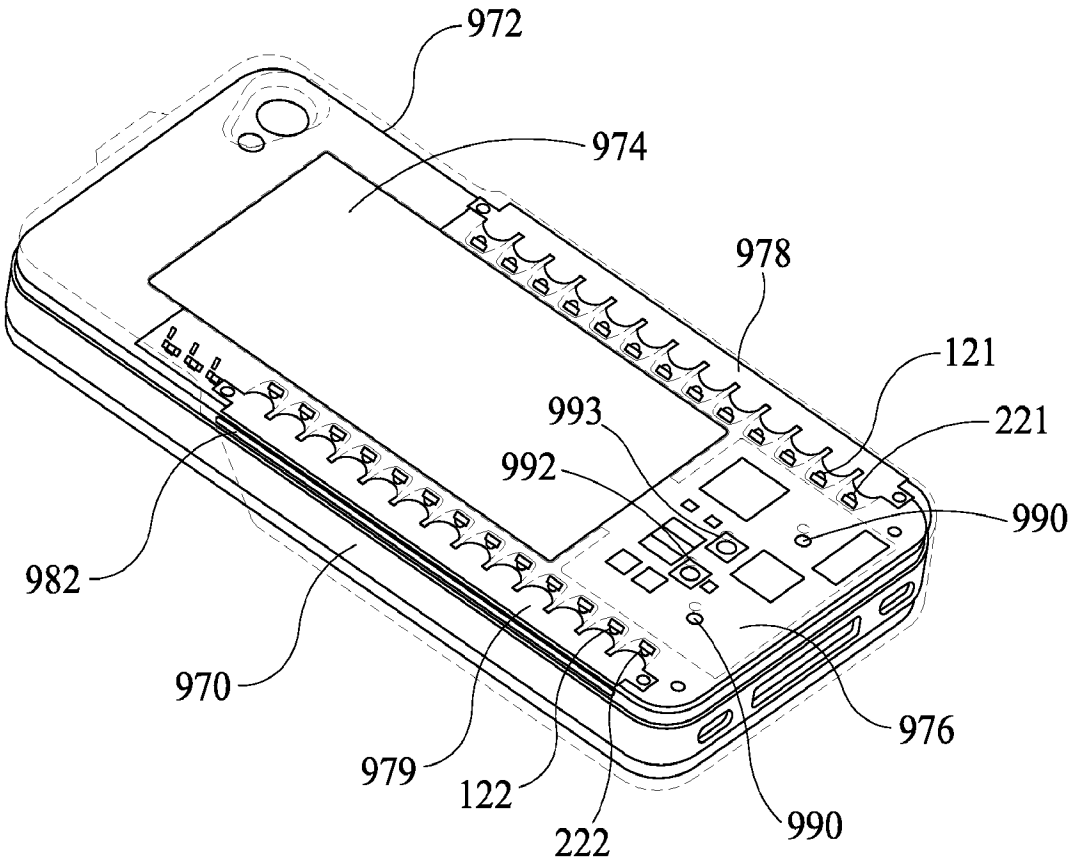


FIG. 38

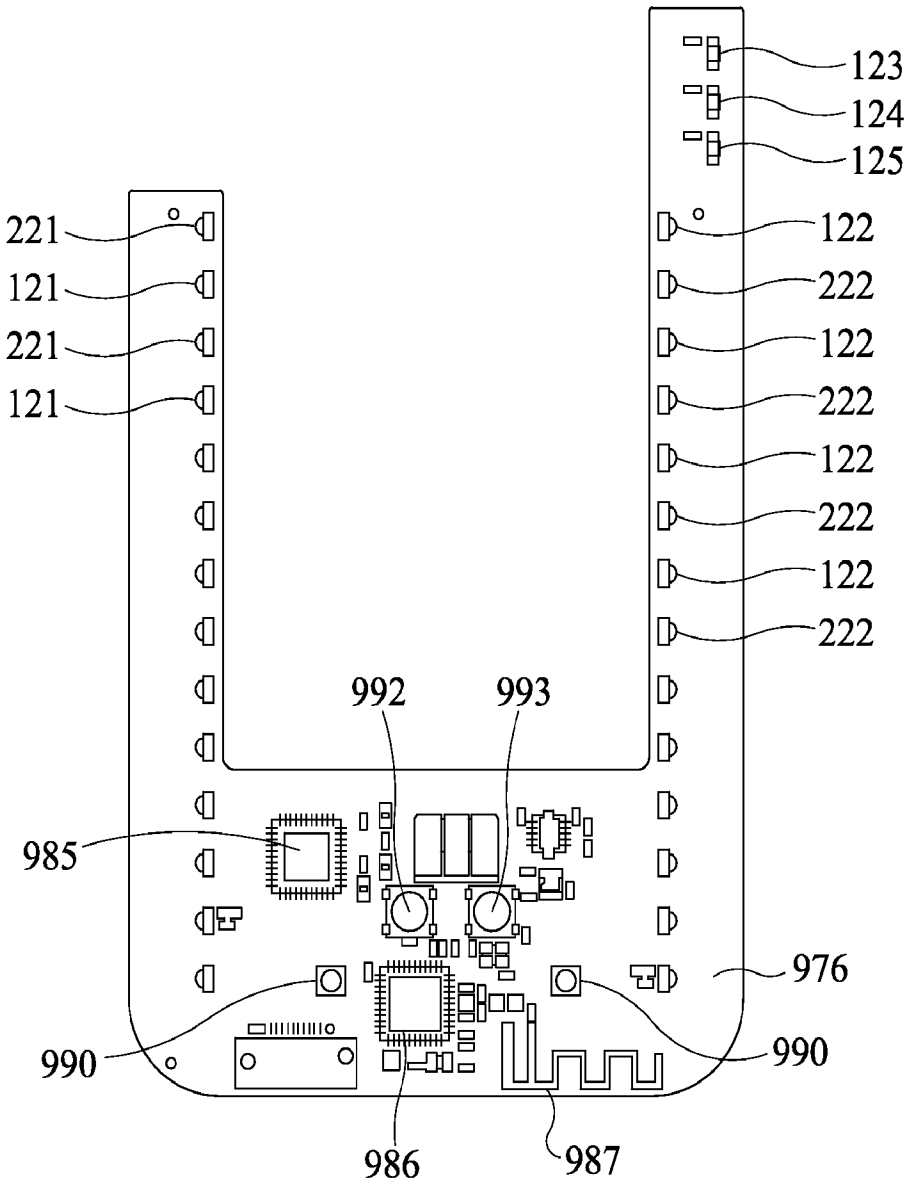

123
124
125
221
121
221
121
122
222
122
222
122
222
122
222
992
993
985
976
990
990
986
987

FIG. 39

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 13/50173

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G06F 3/033 (2013.01)
USPC - 345/158
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC: 345/158

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 345/156-158,174 (keyword limited--see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Patbase; Google Patents; Google Scholar: Google
Search Terms Used: gesture, alarm, clock, waving, phone, proximity, graphical, user, interface, game, controller, touch, edge, weapon, removable, detach, music, sensor, telephone, device, display, screen, housing, casing, case, cover, side, GUI, virtual, offscreen, off

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2006/0161870 A1 (HOTELLING et al.) 20 July 2006 (20.07.2006), para [0045], [0047], [0084], [0174]-[0175], Fig. 5	16-17 --- 15, 18
X --- Y	US 2009/0139778 A1 (BUTLER et al.) 04 June 2009 (04.06.2009), para [0025], [0031], [0034], [0036], [0038], [0042], [0073], [0078], Fig. 6, Fig. 15	19, 23-27, 31, 37 --- 20-22, 28-30, 32-36
Y	BUTLER et al., "SideSight: Multi-touch Interaction Around Small Devices." October 2008. [retrieved on 2014-02-14]. Retrieved from the Internet <URL: http://131.107.65.14/en-us/um/people/shahrami/papers/sidesight.pdf	1-6, 10-15
Y	US 2011/0087963 A1 (BRISEBOIS et al.) 14 April 2011 (14.04.2011), para [0022], [0024], [0047],	1-6, 10-15, 28-30
Y	US 2011/0005367 A1 (HWANG et al.) 13 January 2011 (13.01.2011), Abstract, para [0027], [0032]	5-6
Y	US 2005/0093846 A1 (MARCUS et al.) 05 May 2005 (05.05.2005), [0053], [0067]	12-14
Y	WO 2010/011929 A1 (Clarkson) 28 January 2010 (28.01.2010), para [0023], [0043]-[0044], [0054], [0084], [0097]	20-22, 30, 32-36
Y	US 2008/0134102 A1 (MOVOLD et al.) 05 June 2008 (05.06.2008), [para 0097]	18

☒ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 February 2014 (08.02.2014)	07 MAR 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 13/50173

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/0310005 A1 (Chen et al.) 22 December 2011 (22.12.2011) Entire document	1-6, 10-37
T, A	US 8,643,628 B1 (Eriksson et al.) 04 February 2014 (04.02.2014) Entire document	1-6, 10-37

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 13/50173

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet) .

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

--- See extra sheet ---

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
Claims 1-6, 10-37

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 13/50173

Continuation of Box No. III: Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This application contains the following inventions or groups of inventions that are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-6, 10-18 directed to an electronic device, comprising a housing, display, a plurality of proximity sensors mounted in said housing near the edges of said display for detecting presence of an object outside said display and near the edges of said display and a processor for operating the device responsive to user activation/wave gesture of a graphical user interface(comprising both a displayed portion and a virtual non-displayed portion)/virtual control/device that extends beyond/above the edges of said display.

Group II: Claims 7-9 directed to a camera comprising a housing, view finder, a plurality of proximity sensors mounted in said housing near the edges of said viewfinder for detecting presence of a finger outside said viewfinder and near the edges of said viewfinder and a processor causes the camera to capture a current frame in said viewfinder in response to a user tap at location on the outside of the edges of said viewfinder.

Group III: Claims 19-37 directed to a removable cover for a hand held electronic device comprising a protective cover, plurality of proximity sensors mounted in said cover for detecting user gestures performed outside of the electronic device, a battery, wireless communication circuitry, a processor configured to operate said proximity sensors, and to operate said wireless communication circuitry to transmit commands to the electronic device based on gestures detected by said proximity sensors.

The inventions listed as Groups I - III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical feature of the Group I invention is the electronic device comprising, in combination, a housing, display, a plurality of proximity sensors mounted in said housing near the edges of said display for detecting presence of an object outside said display and near the edges of said display and a processor for operating the device responsive to user activation/wave gesture of a graphical user interface(comprising both a displayed portion and a virtual non-displayed portion)/virtual control/device that extends beyond/above the edges of said display.

The special technical feature of the Group II invention is a camera comprising, in combination, a housing, view finder, a plurality of proximity sensors mounted in said housing near the edges of said viewfinder for detecting presence of a finger outside said viewfinder and near the edges of said viewfinder and a processor causes the camera to capture a current frame in said viewfinder in response to a user tap at location on the outside of the edges of said viewfinder.

The special technical feature of the Group III invention is a removable cover for a hand held electronic device comprising a protective cover, plurality of proximity sensors mounted in said cover for detecting user gestures performed outside of the electronic device, a battery, wireless communication circuitry, a processor configured to operate said proximity sensors, and to operate said wireless communication circuitry to transmit commands to the electronic device based on gestures detected by said proximity sensors.

Groups I and II share the technical features of an electronic device comprising a housing, a plurality of proximity sensors mounted in said housing near the edges and directed outward, for detecting presence of an object outside said housing and near the edges thereof; and a processor mounted in said housing and coupled with said proximity sensors, for operating the electronic device responsive to user activation of elements based on said proximity sensors detecting presence of an object. Groups I-III share the technical features of a plurality of proximity sensors mounted in a housing for detecting user gestures performed outside the housing; and a processor configured to operate said proximity sensors based on gestures detected by said proximity sensors.

These common technical features do not represent an improvement over the prior art of US 2011/0310005 A1 to Chen et al (Published 22 December 2011) that discloses an electronic device comprising a housing, a plurality of proximity sensors mounted in said housing near the edges and directed outward (Fig. 19), for detecting presence of an object and user gestures performed outside said housing and near the edges thereof; and a processor mounted in said housing and coupled with said proximity sensors, for operating the electronic device responsive to user activation of elements based on said proximity sensors detecting presence of an object and or gestures (Fig. 7-16; Abstract; para [0007], etc.).

Thus, the inventions listed as Groups I-III lack unity of invention because they do not share a same or corresponding special technical feature providing a contribution over the prior art.