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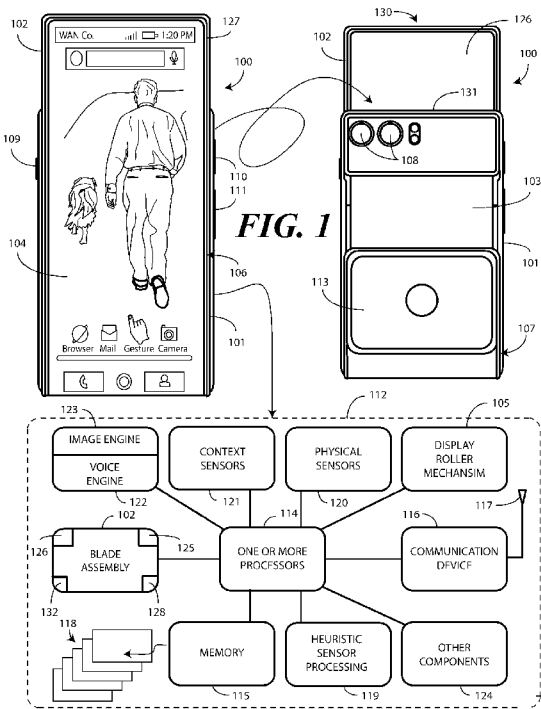
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(54) Title: ELECTRONIC DEVICES WITH TRANSLATING FLEXIBLE DISPLAYS AND CORRESPONDING METHODS FOR PROVIDING HAPTIC FEEDBACK



(57) Abstract: A method in an electronic device includes receiving, by a flexible display carried by a blade assembly that is slidably coupled to a device housing and movable between an extended position and a retracted position, user input. The method then delivers, by a translation mechanism in response to the user input, haptic feedback by causing the blade assembly to translate relative to the device housing with an oscillatory motion.

Electronic Devices with Translating Flexible Displays and Corresponding Methods for Providing Haptic Feedback

BACKGROUND

[001] TECHNICAL FIELD

[002] This disclosure relates generally to electronic devices, and more particularly to electronic devices having flexible displays.

[003] BACKGROUND ART

[004] Portable electronic communication devices, especially smartphones, have become ubiquitous. People all over the world use such devices to stay connected. These devices have been designed in various mechanical configurations. A first configuration, known as a “candy bar,” is generally rectangular in shape, has a rigid form factor, and has a display disposed along a major face of the electronic device. By contrast, a “clamshell” device has a mechanical hinge that allows one housing to pivot relative to the other. A third type of electronic device is a “slider” where two different device housings slide, with one device housing sliding relative to the other.

[005] Some consumers prefer candy bar devices, while others prefer clamshell devices. Still others prefer sliders. The latter two types of devices are convenient in that they are smaller in a closed position than in an open position, thereby fitting more easily in a pocket. While clamshell and slider devices are relatively straight forward mechanically, they can tend to still be bulky when in the closed position due to the fact that two device housings are required. It would thus be desirable to have an improved electronic device and corresponding methods that not only provide a compact geometric form factor while allowing for the use of a larger display surface area as well, but also to provide improved user interface features.

BRIEF DESCRIPTION OF THE DRAWINGS

- [006] FIG. 1 illustrates one explanatory electronic device in accordance with one or more embodiments of the disclosure.
- [007] FIG. 2 illustrates one explanatory electronic device having a translating display moved to a first sliding position where portions of the translating display extend distally away from the device housing of the electronic device.
- [008] FIG. 3 illustrates the explanatory electronic device of FIG. 2 with the translating display moved to a second sliding position where the translating display wraps around, and abuts, the device housing of the electronic device.
- [009] FIG. 4 illustrates the electronic device of FIG. 3 from the rear.
- [010] FIG. 5 illustrates the explanatory electronic device of FIG. 2 with the translating display moved to a third sliding position known as the “peek” position that exposes an image capture device positioned under the translating display when the translating display is in the first sliding position or second sliding position.
- [011] FIG. 6 illustrates one or more explanatory physical sensors suitable for use, alone or in combination, in an electronic device in accordance with one or more embodiments of the disclosure.
- [012] FIG. 7 illustrates one or more explanatory context sensors suitable for use, alone or in combination, in an electronic device in accordance with one or more embodiments of the disclosure.
- [013] FIG. 8 illustrates portions of one explanatory display assembly in an exploded view in accordance with one or more embodiments of the disclosure.
- [014] FIG. 9 illustrates portions of one explanatory display assembly in an exploded view in accordance with one or more embodiments of the disclosure.

- [015] FIG. 10 illustrates one explanatory display assembly in an exploded view in accordance with one or more embodiments of the disclosure.
- [016] FIG. 11 illustrates explanatory display components in accordance with one or more embodiments of the disclosure.
- [017] FIG. 12 illustrates one explanatory display assembly in an undeformed state.
- [018] FIG. 13 illustrates the explanatory display assembly of FIG. 12 in a deformed state.
- [019] FIG. 14 illustrates the explanatory display assembly of FIG. 12 in another deformed state with an exploded view of a deformable portion of the display assembly shown in a magnified view.
- [020] FIG. 15 illustrates a front elevation view of one explanatory electronic device in accordance with one or more embodiments of the disclosure with the blade assembly in an extended position.
- [021] FIG. 16 illustrates a left side elevation view of one explanatory electronic device in accordance with one or more embodiments of the disclosure with the blade assembly in an extended position.
- [022] FIG. 17 illustrates a rear elevation view of one explanatory electronic device in accordance with one or more embodiments of the disclosure with the blade assembly in an extended position.
- [023] FIG. 18 illustrates a front elevation view of one explanatory electronic device in accordance with one or more embodiments of the disclosure with the blade assembly in a retracted position.
- [024] FIG. 19 illustrates a left elevation view of one explanatory electronic device in accordance with one or more embodiments of the disclosure with the blade assembly in a retracted position.

- [025] FIG. 20 illustrates a rear elevation view of one explanatory electronic device in accordance with one or more embodiments of the disclosure with the blade assembly in a retracted position.
- [026] FIG. 21 illustrates a front elevation view of one explanatory electronic device in accordance with one or more embodiments of the disclosure with the blade assembly in a peek position revealing a front facing image capture device.
- [027] FIG. 22 illustrates a rear elevation view of one explanatory electronic device in accordance with one or more embodiments of the disclosure with the blade assembly in a peek position revealing a front facing image capture device.
- [028] FIG. 23 illustrates one explanatory method in accordance with one or more embodiments of the disclosure.
- [029] FIG. 24 illustrates one or more method steps in accordance with one or more embodiments of the disclosure.
- [030] FIG. 25 illustrates one or more method steps in accordance with one or more embodiments of the disclosure.
- [031] FIG. 26 illustrates various embodiments of the disclosure.
- [032] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE DRAWINGS

- [033] Before describing in detail embodiments that are in accordance with the present disclosure, it should be observed that the embodiments reside primarily in combinations of method steps and apparatus components related to a flexible display receiving user input and delivering a haptic response by causing a blade assembly carrying the flexible display that is

slidably coupled to a device housing and movable between an extended position and a retracted position to translate relative to the device housing with an oscillatory motion. Any process descriptions or blocks in flow charts should be understood as representing modules, segments, or portions of code that include one or more executable instructions for implementing specific logical functions or steps in the process.

[034] Alternate implementations are included, and it will be clear that functions may be executed out of order from that shown or discussed, including substantially concurrently or in reverse order, depending on the functionality involved. Accordingly, the apparatus components and method steps have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present disclosure so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein. Further, it is expected that one of ordinary skill, notwithstanding possibly significant effort and many design choices motivated by, for example, available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating methods and devices with minimal experimentation.

[035] Embodiments of the disclosure are now described in detail. Referring to the drawings, like numbers indicate like parts throughout the views. As used in the description herein and throughout the claims, the following terms take the meanings explicitly associated herein, unless the context clearly dictates otherwise: the meaning of “a,” “an,” and “the” includes plural reference, the meaning of “in” includes “in” and “on.”

[036] Relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. As used herein, components may be “operatively coupled” when information can be sent between such

components, even though there may be one or more intermediate or intervening components between, or along the connection path.

[037] The terms “substantially,” “essentially,” “approximately,” “about,” or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within ten percent, in another embodiment within five percent, in another embodiment within one percent and in another embodiment within one-half percent. The term “coupled” as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. Also, reference designators shown herein in parenthesis indicate components shown in a figure other than the one in discussion. For example, talking about a device (10) while discussing figure A would refer to an element, 10, shown in figure other than figure A.

[038] Embodiments of the disclosure provide an electronic device that includes a single device housing. In one or more embodiments, a flexible display is then incorporated into a “blade” assembly that wraps around this single device housing. In one or more embodiments, the blade assembly does this by coupling to a translation mechanism attached to the single device housing.

[039] The translation mechanism is operable to transition the blade assembly around the surfaces of the device housing between an extended position where a blade of the blade assembly extends distally from the device housing and a retracted position where the blade assembly abuts the device housing with the flexible display wrapping around the surfaces of the device housing. In one or more embodiments, the blade assembly can also translate to a “peek” position where movement of the translation mechanism causes the blade assembly to reveal an image capture device situated beneath the blade assembly on the front of the single device housing. Of course, the blade assembly can translate to positions between the extended position, retracted position, and peek position as well.

[040] Advantageously, this ability to cause the blade assembly to translate around the device housing allows the blade assembly to automatically translate toward the extended position when additional front-facing surface area is required, such as when content is to be newly presented on the flexible display. Embodiments of the present disclosure leverage this translation capability of the blade assembly to provide haptic responses to user input as well. Illustrating by example, in one or more embodiments a method in an electronic device comprises receiving, by a flexible display carried by a blade assembly that is slidably coupled to a device housing and moveable between an extended position and a retracted position, user input. In one or more embodiments, the method then delivers, by the translation mechanism in response to the user input, haptic feedback by causing the blade assembly to translate relative to the device housing with an oscillatory motion. This quick “back and forth” motion of the blade assembly causes the oscillating flexible display beneath the user’s finger to provide a tactile sensation in response to the user input in one or more embodiments.

[041] Accordingly, in one or more embodiments an electronic device includes a single device housing with a blade assembly coupled to two major surfaces of the single device housing and wrapping around at least one minor surface of the electronic device where the translation mechanism is positioned such that the blade assembly can slide around, and relative to, the single device housing between a retracted position and an extended. In one or more embodiments, the flexible display is coupled to the blade assembly. When user input is received by the flexible display, a translation mechanism can cause the blade assembly to move rapidly back and forth a short distance to provide haptic feedback to a user.

[042] In one or more embodiments, the flexible display is also surrounded by a silicone border that is co-molded onto a blade substrate and that protects the side edges of the flexible display. In one or more embodiments, the blade assembly engages at least one rotor of the translation mechanism that is situated at an end of the single device housing. When a translation mechanism

situated in the single device housing drives elements coupled to the blade assembly, the flexible display wraps around the rotor and moves to extend the blade of the blade assembly further from, or back toward, the single device housing. When quick, back and forth translations of the blade assembly are made, this feels like a bump, thump, or vibration tactile response to the user.

[043] In one or more embodiments, one end of the flexible display is fixedly coupled to the blade assembly. Meanwhile, the other end of the flexible display is coupled to the tensioner via a flexible substrate that extends beyond the terminal edges of the flexible display. In one or more embodiments, this flexible substrate is a stainless-steel substrate, although other materials can be used.

[044] Illustrating by example, in one or more embodiments the flexible substrate of the flexible display is longer along its major axis than is the flexible display in at least one dimension. Accordingly, at least a first end of the flexible substrate extends distally beyond at least one terminal end of the flexible display. This allows the first end of the flexible substrate to be rigidly coupled to a tensioner. In one or more embodiments, adhesive is used to couple one end of the flexible display to the blade assembly, while one or more fasteners are used to couple the second end of the flexible display to the tensioner, which is carried by the blade assembly.

[045] In one or more embodiments, the translation mechanism comprises an actuator that causes a portion of the blade assembly abutting a first major surface of the single device housing and another portion of the blade assembly abutting a second major surface of the single device housing to slide symmetrically in opposite directions along the single device housing when the blade assembly transitions between the extended position, the retracted position, and the peek position, be it slowly to present or remove content or rapidly in a back and forth oscillatory motion to provide tactile feedback.

[046] Advantageously, embodiments of the disclosure provide an improved haptic feedback mechanism for a flexible display integrated into a blade assembly in a sliding electronic device

having a single device housing that moves the blade assembly back and forth quickly across a short distance to provide tactile sensations to a user. When a tensioner is included, the loading forces applied to the flexible display by the tensioner work to eliminate crumpling and pillowing tendencies that may occur in the flexible display when the haptic feedback is delivered.

[047] In one or more embodiments, the tensioner is rigidly coupled between the blade assembly and the end of the flexible substrate supporting the flexible display. The tensioner can comprise one or more springs that apply a loading force biasing an end of the flexible substrate supporting the flexible display toward an end of the blade assembly. Moreover, the tensioner can be split into two tensioners to allow electronic circuit components and/or conductors powering and controlling the flexible display to be positioned therebetween. Thus, in one or more embodiments the tensioner can be configured as two tensioners each comprising one or more springs biasing a corner end of the flexible substrate supporting the flexible display away from the rotor. The tensioner also helps to avoid the pillowing effect by applying a loading force that eliminates slack from the flat portions of the flexible display defining the partial J-shape.

[048] The actuator of the translation mechanism can take a variety of forms. In some embodiments, the actuator can comprise a dual-shaft motor. The dual shaft motor can be threaded to move translators of the translation mechanism in equal and opposite directions in one or more embodiments. In other embodiments, the dual-shaft motor can be coupled to at least one timing belt.

[049] In one or more embodiments, the blade assembly is coupled to the translator of the translation mechanism. When the translator is actuated, a first portion of the blade assembly abutting a first major surface of the single device housing and a second portion of the blade assembly abutting a second major surface of the single device housing move symmetrically in opposite directions. When haptic feedback is desired, the translation mechanism can move the blade assembly with a back-and-forth motion moving the blade assembly back and forth slightly

toward and from the peek position and toward and from the extended position by an amount sufficient to provide a haptic response to touch input received from a user.

[050] In another embodiment, the actuator comprises a first drive screw and a second drive screw. These drive screws can be coupled together by a gear assembly. When a first portion of the blade assembly is coupled to a translator positioned around the first drive screw, and a second portion of the blade assembly is coupled to another translator positioned around the second drive screw, actuation of either causes the first portion of the blade assembly abutting a first major surface of the single device housing and the second portion of the blade assembly abutting a second major surface of the single device housing to move symmetrically in opposite directions by a rotational amount sufficient to deliver haptic feedback when the first drive screw and the second drive screw rotate.

[051] In still other embodiments, the actuator comprises a first rack, a second rack, and a pinion. The first rack can be coupled to the first portion of the blade assembly while the second rack can be coupled to the second portion of the blade assembly. When the pinion engages both the first rack or the second rack, actuation of either causes the first portion of the blade assembly abutting a first major surface of the single device housing and the second portion of the blade assembly abutting a second major surface of the single device housing to move symmetrically in opposite directions as the first rack and second rack do the same. Other configurations of the actuator will be described below. Still others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[052] Advantageously, embodiments of the disclosure provide an improved sliding mechanism for a flexible display in an electronic device that can not only move the display for content presentation purposes but also deliver haptic feedback in response to touch input by causing a blade assembly, and thus a corresponding flexible display, to translate with an oscillatory motion back and forth relative to a position of the blade assembly relative to the device housing when

user input occurs. While doing so, flexible display and rotor sliding assemblies configured in accordance with embodiments of the disclosure maintain a flat upper portion of a J-shape defined by a flexible display and/or blade assembly while preserving the operability and functionality of the flexible display.

[053] In one or more embodiments, an electronic device comprises a device housing and a blade assembly carrying a blade and a flexible display that is slidably coupled to the device housing. A translation mechanism operable to slide the blade assembly relative to the device housing can move the blade assembly between at least an extended position and a retracted position. One or more processors of the electronic device, in response to the flexible display detecting user input interacting with the flexible display, can cause the translation mechanism to deliver haptic feedback by translating the blade assembly with an oscillatory motion back and forth relative to a position of the blade assembly relative to the device housing when user input occurs. The process can continue each time there is additional user input received by the flexible display.

[054] In one or more embodiments, the haptic feedback provided can change as a function of context. Illustrating by example, if a user actuation target is presented on the flexible display and the touch input interacting with the flexible display is that of a user's finger touching the user actuation target, the oscillatory motion may occur with a predefined oscillatory pattern. However, if the user's finger misses the user actuation target, the oscillatory motion may occur with another oscillatory pattern that is different. Thus, the oscillatory motion may occur with a predefined oscillatory pattern when the user interface occurs at a location corresponding to a user actuation target presented on the flexible display. However, the oscillatory motion may occur with another predefined oscillatory pattern when the user input occurs at another location failing to correspond to the user actuation target presented on the flexible display, and so forth.

[055] In one or more embodiments, a method for an electronic device comprises detecting, by one or more processors, touch input interacting with a flexible display carried by a blade assembly that is slidably coupled to a device housing and moveable between an extended position, a retracted position, and a peek position. In one or more embodiments, in response to touch input, a translation mechanism operable with the one or more processors translates the blade assembly with a back-and-forth motion moving the blade assembly slightly toward the peek position and then toward the extended position by an amount necessary to provide a haptic response to the touch input.

[056] Other advantages offered by embodiments of the disclosure will be described below. Still others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[057] Turning now to FIG. 1, illustrated therein is one exemplary electronic device 100 configured in accordance with one or more embodiments of the disclosure. The electronic device 100 of FIG. 1 is a portable electronic device. For illustrative purposes, the electronic device 100 is shown as a smartphone. However, the electronic device 100 could be any number of other devices as well, including tablet computers, gaming devices, multimedia players, and so forth. Still other types of electronic devices can be configured in accordance with one or more embodiments of the disclosure as will be readily appreciated by those of ordinary skill in the art having the benefit of this disclosure.

[058] The electronic device 100 includes a single device housing 101. In one or more embodiments, a blade assembly 102 carrying a flexible display 104 wraps around the single device housing 101. As will be described in more detail below, in one or more embodiments the blade assembly 102 is configured to “slide” along the first major surface (covered by the flexible display in the front view of the electronic device 100 on the left side of FIG. 1) of the single device housing 101 and second major surface 103 situated on the rear side of the single device housing 101.

[059] In one or more embodiments the single device housing 101 is manufactured from a rigid material such as a rigid thermoplastic, metal, or composite material, although other materials can be used. Illustrating by example, in one illustrative embodiment the single device housing 101 is manufactured from aluminum. Still other constructs will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[060] In the illustrative embodiment of FIG. 1, the blade assembly 102 carries the flexible display 104. The flexible display 104 can optionally be touch-sensitive. Users can deliver user input to the flexible display 104 of such an embodiment by delivering touch input from a finger, stylus, or other objects disposed proximately with the flexible display 104.

[061] In one embodiment, the flexible display 104 is configured as an organic light emitting diode (OLED) display fabricated on a flexible plastic substrate. The blade assembly 102 is fabricated on a flexible substrate as well. This allows the blade assembly 102 and flexible display 104 to deform around a display roller mechanism 105 when a first portion 106 of the blade assembly 102 abutting a first major surface of the single device housing 101 and a second portion 107 of the blade assembly 102 abutting a second major surface 103 of the single device housing 101 move symmetrically in opposite directions around the single device housing 101. In one or more embodiments, the blade assembly 102 and flexible display 104 are both constructed on flexible metal substrates can allow each to bend with various bending radii around the display roller mechanism 105.

[062] In one or more embodiments the flexible display 104 may be formed from multiple layers of flexible material such as flexible sheets of polymer or other materials. In this illustrative embodiment, the flexible display 104 is fixedly coupled to the blade assembly 102, which wraps around the display roller mechanism 105.

[063] Features can be incorporated into the single device housing 101. Examples of such features include one or more cameras or image capture devices 108 or an optional speaker port. In

this illustrative embodiment, user interface components 109,110,111, which may be buttons, fingerprint sensors, or touch sensitive surfaces, can also be disposed along the surfaces of the single device housing 101. Any of these features are shown being disposed on the side surfaces of the electronic device 100 could be located elsewhere. In other embodiments, these features may be omitted.

[064] A block diagram schematic 112 of the electronic device 100 is also shown in FIG. 1. The block diagram schematic 112 includes one or more electronic components that can be coupled to a printed circuit board assembly disposed within the single device housing 101. Alternatively, the electronic components may be carried by the blade assembly 102. Illustrating by example, in one or more embodiments electronic components can be positioned beneath a “backpack” 113 carried by the blade assembly 102.

[065] The components of the block diagram schematic 112 can be electrically coupled together by conductors or a bus disposed along one or more printed circuit boards. For example, some components of the block diagram schematic 112 can be configured as a first electronic circuit fixedly situated within the single device housing 101, while other components of the block diagram schematic 112 can be configured as a second electronic circuit carried by the blade assembly 102 in the backpack 113. A flexible substrate can then extend from the first electronic circuit in the single device housing 101 to the second electronic circuit carried by the blade assembly 102 in the backpack 113 to electrically couple the first electronic circuit to the second electronic circuit.

[066] The illustrative block diagram schematic 112 of FIG. 1 includes many different components. Embodiments of the disclosure contemplate that the number and arrangement of such components can change depending on the particular application. Accordingly, electronic devices configured in accordance with embodiments of the disclosure can include some

components that are not shown in FIG. 1, and other components that are shown may not be needed and can therefore be omitted.

[067] In one or more embodiments, the electronic device 100 includes one or more processors 114. In one embodiment, the one or more processors 114 can include an application processor and, optionally, one or more auxiliary processors. One or both of the application processor or the auxiliary processor(s) can include one or more processors. One or both of the application processor or the auxiliary processor(s) can be a microprocessor, a group of processing components, one or more ASICs, programmable logic, or other type of processing device.

[068] The application processor and the auxiliary processor(s) can be operable with the various components of the electronic device 100. Each of the application processor and the auxiliary processor(s) can be configured to process and execute executable software code to perform the various functions of the electronic device 100. A storage device, such as memory 115, can optionally store the executable software code used by the one or more processors 114 during operation.

[069] In one embodiment, the one or more processors 114 are responsible for running the operating system environment of the electronic device 100. The operating system environment can include a kernel and one or more drivers, and an application service layer, and an application layer. The operating system environment can be configured as executable code operating on one or more processors or control circuits of the electronic device 100. The application layer can be responsible for executing application service modules. The application service modules may support one or more applications or “apps.” The applications of the application layer can be configured as clients of the application service layer to communicate with services through application program interfaces (APIs), messages, events, or other inter-process communication interfaces. Where auxiliary processors are used, they can be used to execute input/output functions, actuate user feedback devices, and so forth.

[070] In this illustrative embodiment, the electronic device 100 also includes a communication device 116 that can be configured for wired or wireless communication with one or more other devices or networks. The networks can include a wide area network, a local area network, and/or personal area network. The communication device 116 may also utilize wireless technology for communication, such as, but are not limited to, peer-to-peer or ad hoc communications such as HomeRF, Bluetooth and IEEE 802.11, and other forms of wireless communication such as infrared technology. The communication device 116 can include wireless communication circuitry, one of a receiver, a transmitter, or transceiver, and one or more antennas 117.

[071] In one embodiment, the one or more processors 114 can be responsible for performing the primary functions of the electronic device 100. For example, in one embodiment the one or more processors 114 comprise one or more circuits operable with one or more user interface devices, which can include the flexible display 104, to present, images, video, split-screen content, or other presentation information to a user. The executable software code used by the one or more processors 114 can be configured as one or more modules 118 that are operable with the one or more processors 114. Such modules 118 can store instructions, control algorithms, logic steps, and so forth.

[072] In one embodiment, the one or more processors 114 are responsible for running the operating system environment of the electronic device 100. The operating system environment can include a kernel and one or more drivers, and an application service layer, and an application layer. The operating system environment can be configured as executable code operating on one or more processors or control circuits of the electronic device 100. The application layer can be responsible for executing application service modules. The application service modules may support one or more applications or “apps.” The applications of the application layer can be configured as clients of the application service layer to communicate with services through application program interfaces (APIs), messages, events, or other inter-process communication

interfaces. Where auxiliary processors are used, they can be used to execute input/output functions, actuate user feedback devices, and so forth.

[073] In one embodiment, the one or more processors 114 may generate commands or execute control operations based on information received from the various sensors of the electronic device 100. As shown in FIG. 1, these sensors can be categorized into physical sensors 120 and context sensors 121.

[074] Generally speaking, physical sensors 120 include sensors configured to sense or determine physical parameters indicative of conditions in an environment about the electronic device 100. Illustrating by example, the physical sensors 120 can include devices for determining information such as motion, acceleration, orientation, proximity to people and other objects, lighting, capturing images, and so forth. The physical sensors 120 can include various combinations of microphones, location detectors, temperature sensors, barometers, proximity sensor components, proximity detector components, wellness sensors, touch sensors, cameras, audio capture devices, and so forth. Many examples of physical sensors 120 will be described below with reference to FIG. 6. Others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[075] By contrast, the context sensors 121 do not measure physical conditions or parameters. Instead, they infer context from data of the electronic device. Illustrating by example, when a physical sensor 120 includes a camera or intelligent imager, the context sensors 121 can use data captured in images to infer contextual cues. An emotional detector may be operable to analyze data from a captured image to determine an emotional state. The emotional detector may identify facial gestures such as a smile or raised eyebrow to infer a person's silently communicated emotional state, e.g., joy, anger, frustration, and so forth. Other context sensors 121 may analyze other data to infer context, including calendar events, user profiles, device operating states,

energy storage within a battery, application data, data from third parties such as web services and social media servers, alarms, time of day, behaviors a user repeats, and other factors.

[076] The context sensors 121 can be configured as either hardware components, or alternatively as combinations of hardware components and software components. The context sensors 121 can be configured to collect and analyze non-physical parametric data.

[077] Examples of the physical sensors 120 and the context sensors 121 are shown in FIGS. 6 and 7. These examples are illustrative only, as other physical sensors 120 and context sensors 121 will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[078] Turning briefly to FIG. 6, illustrated therein are various examples of the physical sensors 120. In one or more embodiments, the physical sensors 120 sense or determine physical parameters indicative of conditions in an environment about an electronic device. FIG. 6 illustrates several examples physical sensors 120. It should be noted that those shown in FIG. 6 are not comprehensive, as others will be obvious to those of ordinary skill in the art having the benefit of this disclosure. Additionally, it should be noted that the various physical sensors 120 shown in FIG. 6 could be used alone or in combination. Accordingly, many electronic devices will employ only subsets of the physical sensors 120 shown in FIG. 6, with the particular subset chosen being defined by device application.

[079] A first example of a physical sensor is a touch sensor 601. The touch sensor 601 can include a capacitive touch sensor, an infrared touch sensor, resistive touch sensors, or another touch-sensitive technology. Capacitive touch-sensitive devices include a plurality of capacitive sensors, e.g., electrodes, which are disposed along a substrate. Each capacitive sensor is configured, in conjunction with associated control circuitry, e.g., the one or more processors (114), to detect an object in close proximity with – or touching – the surface of the display or the housing of an electronic device by establishing electric field lines between pairs of capacitive sensors and then detecting perturbations of those field lines.

[080] The electric field lines can be established in accordance with a periodic waveform, such as a square wave, sine wave, triangle wave, or other periodic waveform that is emitted by one sensor and detected by another. The capacitive sensors can be formed, for example, by disposing indium tin oxide patterned as electrodes on the substrate. Indium tin oxide is useful for such systems because it is transparent and conductive. Further, it is capable of being deposited in thin layers by way of a printing process. The capacitive sensors may also be deposited on the substrate by electron beam evaporation, physical vapor deposition, or other various sputter deposition techniques.

[081] Another example of a physical sensor 120 is a geo-locator that serves as a location detector 602. In one embodiment, location detector 602 is operable to determine location data when an image is captured from a constellation of one or more earth orbiting satellites, or from a network of terrestrial base stations to determine an approximate location. Examples of satellite positioning systems suitable for use with embodiments of the present invention include, among others, the Navigation System with Time and Range (NAVSTAR) Global Positioning Systems (GPS) in the United States of America, and other similar satellite positioning systems. The location detector 602 can make location determinations autonomously or with assistance from terrestrial base stations, for example those associated with a cellular communication network or other ground-based network, or as part of a Differential Global Positioning System (DGPS), as is well known by those having ordinary skill in the art. The location detector 602 may also be able to determine location by locating or triangulating terrestrial base stations of a traditional cellular network, or from other local area networks, such as Wi-Fi networks.

[082] Another physical sensor 120 is a near field communication circuit 603. The near field communication circuit 603 can be included for communication with local area networks to receive information regarding the context of the environment in which an electronic device is located. Illustrating by example, the near field communication circuit 603 may obtain information

such as weather information and location information. If, for example, a user is at a museum, they may be standing near an exhibit that can be identified with near field communication. This identification can indicate that the electronic device is both indoors and at a museum.

Accordingly, if the user requests additional information about an artist or a painting, there is a higher probability that the question is a device command asking the one or more processors (114) to search for than information with a web browser. Alternatively, the near field communication circuit 603 can be used to receive contextual information from kiosks and other electronic devices. The near field communication circuit 603 can also be used to obtain image or other data from social media networks. Examples of suitable near field communication circuits include Bluetooth communication circuits, IEEE 801.11 communication circuits, infrared communication circuits, magnetic field modulation circuits, and Wi-Fi circuits.

[083] Another example of a physical sensor 120 is the motion detector 604. Illustrating by example, an accelerometer, gyroscopes, or other device can be used as a motion detector 604 in an electronic device. Using an accelerometer as an example, an accelerometer can be included to detect motion of the electronic device. Additionally, the accelerometer can be used to sense some of the gestures of the user, such as one talking with their hands, running, or walking.

[084] The motion detector 604 can also be used to determine the spatial orientation of an electronic device as well in three-dimensional space by detecting a gravitational direction. In addition to, or instead of, an accelerometer, an electronic compass can be included to detect the spatial orientation of the electronic device relative to the earth's magnetic field. Similarly, one or more gyroscopes can be included to detect rotational motion of the electronic device.

[085] Another example of a physical sensor 120 is a force sensor 605. The force sensor can take various forms. For example, in one embodiment, the force sensor comprises resistive switches or a force switch array configured to detect contact with either the display or the housing of an electronic device. The array of resistive switches can function as a force-sensing layer, in

that when contact is made with either the surface of the display or the housing of the electronic device, changes in impedance of any of the switches may be detected. The array of switches may be any of resistance sensing switches, membrane switches, force-sensing switches such as piezoelectric switches, or other equivalent types of technology. In another embodiment, the force sensor can be capacitive. In yet another embodiment, piezoelectric sensors can be configured to sense force as well. For example, where coupled with the lens of the display, the piezoelectric sensors can be configured to detect an amount of displacement of the lens to determine force. The piezoelectric sensors can also be configured to determine force of contact against the housing of the electronic device rather than the display.

[086] Another example of physical sensors 120 includes proximity sensors. The proximity sensors fall in to one of two camps: active proximity sensors and “passive” proximity sensors. These are shown as proximity detector components 606 and proximity sensor components 607 in FIG. 6. Either the proximity detector components 606 or the proximity sensor components 607 can be generally used for gesture control and other user interface protocols., some examples of which will be described in more detail below.

[087] As used herein, a “proximity sensor component” comprises a signal receiver only that does not include a corresponding transmitter to emit signals for reflection off an object to the signal receiver. A signal receiver only can be used due to the fact that a user’s body or other heat generating object external to device, such as a wearable electronic device worn by user, serves as the transmitter. Illustrating by example, in one the proximity sensor components 607 comprise a signal receiver to receive signals from objects external to the housing of an electronic device. In one embodiment, the signal receiver is an infrared signal receiver to receive an infrared emission from an object such as a human being when the human is proximately located with the electronic device. In one or more embodiments, the proximity sensor component is configured to receive infrared wavelengths of about four to about ten micrometers. This wavelength range is

advantageous in one or more embodiments in that it corresponds to the wavelength of heat emitted by the body of a human being.

[088] Additionally, detection of wavelengths in this range is possible from farther distances than, for example, would be the detection of reflected signals from the transmitter of a proximity detector component. In one embodiment, the proximity sensor components 607 have a relatively long detection range so as to detect heat emanating from a person's body when that person is within a predefined thermal reception radius. For example, the proximity sensor component may be able to detect a person's body heat from a distance of about ten feet in one or more embodiments. The ten-foot dimension can be extended as a function of designed optics, sensor active area, gain, lensing gain, and so forth.

[089] Proximity sensor components 607 are sometimes referred to as a "passive IR system" due to the fact that the person is the active transmitter. Accordingly, the proximity sensor component 607 requires no transmitter since objects disposed external to the housing deliver emissions that are received by the infrared receiver. As no transmitter is required, each proximity sensor component 607 can operate at a very low power level.

[090] In one embodiment, the signal receiver of each proximity sensor component 607 can operate at various sensitivity levels so as to cause the at least one proximity sensor component 607 to be operable to receive the infrared emissions from different distances. For example, the one or more processors (114) can cause each proximity sensor component 607 to operate at a first "effective" sensitivity so as to receive infrared emissions from a first distance. Similarly, the one or more processors (114) can cause each proximity sensor component 607 to operate at a second sensitivity, which is less than the first sensitivity, so as to receive infrared emissions from a second distance, which is less than the first distance. The sensitivity change can be made by causing the one or more processors (114) to interpret readings from the proximity sensor component 607 differently.

[091] By contrast, proximity detector components 606 include a signal emitter and a corresponding signal receiver. While each proximity detector component 606 can be any one of various types of proximity sensors, such as but not limited to, capacitive, magnetic, inductive, optical/photoelectric, imager, laser, acoustic/sonic, radar-based, Doppler-based, thermal, and radiation-based proximity sensors, in one or more embodiments the proximity detector components 606 comprise infrared transmitters and receivers. The infrared transmitters are configured, in one embodiment, to transmit infrared signals having wavelengths of about 860 nanometers, which is one to two orders of magnitude shorter than the wavelengths received by the proximity sensor components. The proximity detector components can have signal receivers that receive similar wavelengths, i.e., about 860 nanometers.

[092] In one or more embodiments, each proximity detector component 606 can be an infrared proximity sensor set that uses a signal emitter that transmits a beam of infrared light that reflects from a nearby object and is received by a corresponding signal receiver. Proximity detector components 606 can be used, for example, to compute the distance to any nearby object from characteristics associated with the reflected signals. The reflected signals are detected by the corresponding signal receiver, which may be an infrared photodiode used to detect reflected light emitting diode (LED) light, respond to modulated infrared signals, and/or perform triangulation of received infrared signals.

[093] Another example of a physical sensor is a moisture detector 608. A moisture detector 608 can be configured to detect the amount of moisture on or about the display or the housing of the electronic device. This can indicate various forms of context. Sometimes, it can indicate rain or drizzle in the environment about the electronic device. Accordingly, if a user is frantically asking “Call a cab!” the fact that moisture is present may increase the likelihood that this ask is a device command. The moisture detector 608 can be realized in the form of an impedance sensor that measures impedance between electrodes. As moisture can be due to external conditions, e.g., rain,

or user conditions, perspiration, the moisture detector 608 can function in tandem with ISFETS configured to measure pH or amounts of NaOH in the moisture or a galvanic sensor 609 to determine not only the amount of moisture, but whether the moisture is due to external factors, perspiration, or combinations thereof.

[094] An intelligent imager 610 can be configured to capture an image of an object and determine whether the object matches predetermined criteria. For example, the intelligent imager 610 operate as an identification module configured with optical recognition such as include image recognition, character recognition, visual recognition, facial recognition, color recognition, shape recognition and the like. Advantageously, the intelligent imager 610 can be used as a facial recognition device to determine the identity of one or more persons detected about an electronic device.

[095] For example, in one embodiment when the one or more proximity sensor components 607 detect a person, the intelligent imager 610 can capture a photograph of that person. The intelligent imager 610 can then compare the image to a reference file stored in memory (115), to confirm beyond a threshold authenticity probability that the person's face sufficiently matches the reference file. Beneficially, optical recognition allows the one or more processors (114) to execute control operations only when one of the persons detected about the electronic device are sufficiently identified as the owner of the electronic device.

[096] In addition to capturing photographs, the intelligent imager 610 can function in other ways as well. For example, in some embodiments the intelligent imager 610 can capture multiple successive pictures to capture more information that can be used to determine social cues. Alternatively, the intelligent imager 610 can capture or video frames, with or without accompanying metadata such as motion vectors. This additional information captured by the intelligent imager 610 can be used to detect richer social cues that may be inferred from the captured data.

[097] A barometer 611 can sense changes in air pressure due to environmental and/or weather changes. In one embodiment, the barometer 611 includes a cantilevered mechanism made from a piezoelectric material and disposed within a chamber. The cantilevered mechanism functions as a pressure sensitive valve, bending as the pressure differential between the chamber and the environment changes. Deflection of the cantilever ceases when the pressure differential between the chamber and the environment is zero. As the cantilevered material is piezoelectric, deflection of the material can be measured with an electrical current.

[098] A gaze detector 612 can comprise sensors for detecting the user's gaze point. The gaze detector 612 can optionally include sensors for detecting the alignment of a user's head in three-dimensional space. Electronic signals can then be delivered from the sensors to the gaze detection processing for computing the direction of user's gaze in three-dimensional space. The gaze detector 612 can further be configured to detect a gaze cone corresponding to the detected gaze direction, which is a field of view within which the user may easily see without diverting their eyes or head from the detected gaze direction. The gaze detector 612 can be configured to alternately estimate gaze direction by inputting to the gaze detection processing images representing a photograph of a selected area near or around the eyes. It will be clear to those of ordinary skill in the art having the benefit of this disclosure that these techniques are explanatory only, as other modes of detecting gaze direction can be substituted in the gaze detector 612 of FIG. 6.

[099] A light sensor 613 can detect changes in optical intensity, color, light, or shadow in the environment of an electronic device. This can be used to make inferences about context such as weather or other cues. For example, if the light sensor 613 detects low-light conditions in the middle of the day when the location detector 602 indicates that the electronic device is outside, this can be due to cloudy conditions, fog, or haze. An infrared sensor can be used in conjunction with, or in place of, the light sensor 613. The infrared sensor can be configured to detect thermal

emissions from an environment about an electronic device. Where, for example, the infrared sensor detects heat on a warm day, but the light sensor detects low-light conditions, this can indicate that the electronic device is in a room where the air conditioning is not properly set. Similarly, a temperature sensor 614 can be configured to monitor temperature about an electronic device.

[0100] The physical sensors 120 can also include an audio capture device 615. In one embodiment, the audio capture device 615 includes one or more microphones to receive acoustic input. While the one or more microphones can be used to sense voice input, voice commands, and other audio input, in some embodiments they can be used as environmental sensors to sense environmental sounds such as rain, wind, and so forth.

[0101] In one embodiment, the one or more microphones include a single microphone. However, in other embodiments, the one or more microphones can include two or more microphones. Where multiple microphones are included, they can be used for selective beam steering to, for instance, determine from which direction a sound emanated. Illustrating by example, a first microphone can be located on a first side of the electronic device for receiving audio input from a first direction, while a second microphone can be placed on a second side of the electronic device for receiving audio input from a second direction. The one or more processors (114) can then select between the first microphone and the second microphone to beam steer audio reception toward the user. Alternatively, the one or more processors (114) can process and combine the signals from two or more microphones to perform beam steering.

[0102] In one embodiment, the audio capture device 615 comprises an “always ON” audio capture device. As such, the audio capture device 615 is able to capture audio input at any time that an electronic device is operational. As noted above, in one or more embodiments, the one or more processors, which can include a digital signal processor, can identify whether one or more device commands are present in the audio input captured by the audio capture device 615.

[0103] One further example of the physical sensors 120 is a hygrometer 616. The hygrometer 616 can be used to detect humidity, which can indicate that a user is outdoors or is perspiring. As noted above, the illustrative physical sensors of FIG. 6 are not comprehensive. Numerous others could be added. For example, a wind-speed monitor could be included to detect wind. Accordingly, the physical sensors 120 of FIG. 6 are illustrative only, as numerous others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0104] Turning briefly now to FIG. 7, illustrated therein are various examples of context sensors 121. As with FIG. 6, the examples shown in FIG. 7 do not constitute a comprehensive list. Numerous other context sensors 121 will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0105] In one embodiment, a mood detector 701 can infer a person's mood based upon contextual information received from the physical sensors (120). For example, if the intelligent imager (501) captures a picture, multiple successive pictures, video, or other information from which a person can be identified as the owner of the electronic device, and she is crying in the picture, multiple successive pictures, video, or other information, the mood detector 701 can infer that she is either happy or sad. Similarly, if the audio capture device captures a user's voice and the user is yelling or cursing, the mood detector 701 can infer that the user is likely angry or upset.

[0106] The emotional detector 702 can function in a similar manner to infer a person's emotional state from contextual information received from the physical sensors (120). Illustrating by example, if the intelligent imager (501) captures a picture, multiple successive pictures, video, or other information relating to of the owner of an electronic device, the emotional detector 702 can infer their silently communicated emotional state, e.g., joy, anger, frustration, and so forth. This can be inferred from, for example, facial gestures such as a raised eyebrow, grin, or other feature. In one or more embodiments, such emotional cues can indicate the user is intending to issue a command to the electronic device. Alternatively, emotion can be detected from voice inflections,

or words used. If someone screams, “I am mad at you,” there are likely negative emotional issues involved, for example.

[0107] Calendar information and events 720 can be used to detect social cues. If, for example, a calendar event indicates that a birthday party is occurring, this can imply festive and jovial social cues. However, if a funeral is occurring, it is unlikely that a user will be issuing device commands to an electronic device as funerals tend to be quiet affairs.

[0108] Wellness information 703 can be used to detect social cues. If, for example, wellness information 703 indicates that a person’s heart rate is high, and they are perspiring, and the location information 715 indicates that a person is in an alley of a city, and the time-of-day information 708 indicates that it’s 3AM, the person may be under duress. Accordingly, the command “Call 911” is highly likely to be a device command.

[0109] Alarm information 704 can be used to detect social cues. If an alarm has just sounded at 6:00 AM, the command “snooze” is likely to be a device command. Personal identification information 705 can be used to detect social cues as well. If a person is a diabetic, and wellness sensors show them to be clammy and sweaty, this could be due to low insulin. Accordingly, the command “Call 911” is highly likely to be a device command.

[0110] Device usage data 706 can indicate social cues. If a person is searching the web, and an incoming call is received, the command “decline” is likely to be a device command. Energy storage 707 within an electronic device can be used to indicate a social cue. Device operating mode information 709 can be used in a similar fashion. When energy storage drops to, for example, ten percent, the command “shut down all non-critical apps” is likely to be a device command.

[0111] Consumer purchase information 711 can certainly indicate social cues. If, for example, a person is a sommelier and frequently purchases wine, when viewing a web browser and finding a

bottle of '82 Lafite for under \$1000, the command “buy that wine now” is likely to be a device command.

[0112] Device usage profiles 712 can be used to infer social cues as well. If, for example, a person never uses an electronic device between 10:00 PM and 6:00 AM due to the fact that they are sleeping, if they happen to talk in their sleep and say, “order a pizza – I’m starving,” this is not likely to be a device command.

[0113] Organizations can have formal rules and policies 710, such as meetings cannot last more than an hour without a break, one must take a lunch break between noon and 2:00 PM, and brainstorming sessions occur every morning between 9:00 and 10:00 AM. Similarly, families can have similar rules and policies 713, such as dinner occurs between 6:00 and 7:00 PM. This information can be used to infer social cues such as whether a person is likely to be in conversation with other people. When this is the case, spoken questions are less likely to be device commands. By contrast, when a user is likely to be alone, spoken commands are more likely to be device commands.

[0114] Application data 734 can indicate social cues. If a person frequently interacts with word processing applications during the day, the commands “cut” and “paste” are more likely to be device commands that they would for someone who instead plays video games with flying birds. Device settings 716 can indicate social cues as well. If a user sets their electronic device to alarm clock mode, it may be likely that they are sleeping and are not issuing device commands.

[0115] Social media 718 information can indicate social cues. For example, in one embodiment information relating to multi-modal social cues from an environment about the electronic device can be inferred from retrieving information from a social media server. For example, real time searches, which may be a keyword search, image search, or other search, of social media services can find images, posts, and comments relating to a location determined by the location information 715. Images posted on a social media service server that were taken at the same

location may reveal multi-modal social cues. Alternatively, commentary regarding the location may imply social cues. Information from third party servers 717 can be used in this manner as well.

[0116] One further example of the context sensors 121 is repetitive behavior information 719. If, for example, a person always stops at a coffee shop between 8:00 and 8:15 AM on their way to work, the command, “Pay for the coffee,” is likely to be a device command. As with FIG. 6 above, the physical sensors of FIG. 6 do not constitute a comprehensive list. Context sensors 121 can be any type of device that infers context from data of the electronic device. The context sensors 121 can be configured as either hardware components, or alternatively as combinations of hardware components and software components. The context sensors 121 can analyze information to, for example, not only detect the user, but also to determine the social cues and emotional effect of other people in the vicinity of the electronic device, thereby further informing inferences about the user's intent and what executable control commands are appropriate given this composite social context.

[0117] The context sensors 121 can be configured to collect and analyze non-physical parametric data. While some are shown in FIG. 7, numerous others could be added. Accordingly, the context sensors 121 of FIG. 7 are illustrative only, as numerous others will be obvious to those of ordinary skill in the art having the benefit of this disclosure. It should be noted that one or both of the physical sensors (120) or the context sensors 121, when used in combination, can be cascaded in a predefined order to detect a plurality of multi-modal social cues to determine whether the device command is intended for the electronic device.

[0118] Turning now back to FIG. 1, in one or more embodiments a heuristic sensor processor 119 can be operable with both the physical sensors 120 and the context sensors 121 to detect, infer, capture, and otherwise determine when multi-modal social cues are occurring in an environment about an electronic device. In one embodiment, the heuristic sensor processor 119

determines, from one or both of the physical sensors 120 or the context sensors 121, assessed contexts and frameworks using adjustable algorithms of context assessment employing information, data, and events. These assessments may be learned through repetitive data analysis. Alternatively, a user may employ the user interface of the electronic device 100 to enter various parameters, constructs, rules, and/or paradigms that instruct or otherwise guide the heuristic sensor processor 119 in detecting multi-modal social cues, emotional states, moods, and other contextual information. The heuristic sensor processor 119 can comprise an artificial neural network or other similar technology in one or more embodiments.

[0119] In one or more embodiments, the heuristic sensor processor 119 is operable with the one or more processors 114. In some embodiments, the one or more processors 114 can control the heuristic sensor processor 119. In other embodiments, the heuristic sensor processor 119 can operate independently, delivering information gleaned from detecting multi-modal social cues, emotional states, moods, and other contextual information to the one or more processors 114. The heuristic sensor processor 119 can receive data from one or both of the physical sensors 120 or the context sensors 121. In one or more embodiments, the one or more processors 114 are configured to perform the operations of the heuristic sensor processor 119.

[0120] In one or more embodiments, the block diagram schematic 112 includes a voice interface engine 122. The voice interface engine 122 can include hardware, executable code, and speech monitor executable code in one embodiment. The voice interface engine 122 can include, stored in memory 115, basic speech models, trained speech models, or other modules that are used by the voice interface engine 122 to receive and identify voice commands that are received with audio input captured by an audio capture device. In one embodiment, the voice interface engine 122 can include a voice recognition engine. Regardless of the specific implementation utilized in the various embodiments, the voice interface engine 122 can access various speech models to identify speech commands.

[0121] In one embodiment, the voice interface engine 122 is configured to implement a voice control feature that allows a user to speak a specific device command to cause the one or more processors 114 to execute a control operation. For example, the user may say, "How tall is the Sears Tower?" This question comprises a device command requesting the one or more processors to retrieve, with the communication device 116, information from a remote server, perhaps across the Internet, to answer the question. Consequently, this device command can cause the one or more processors 114 to access an application module, such as a web browser, to search for the answer and then deliver the answer as audible output via an audio output of the other components 124. In short, in one embodiment the voice interface engine 122 listens for voice commands, processes the commands and, in conjunction with the one or more processors 114, returns an output that is the result of the user's intent.

[0122] The block diagram schematic 112 can also include an image/gaze detection-processing engine 123. The image/gaze detection-processing engine 123 can be operable with the physical sensors 120, such as a camera or intelligent imager, to process information to detect a user's gaze point. The image/gaze detection-processing engine 123 can optionally include sensors for detecting the alignment of a user's head in three-dimensional space. Electronic signals can then be delivered from the sensors to the image/gaze detection-processing engine 123 for computing the direction of user's gaze in three-dimensional space. The image/gaze detection-processing engine 123 can further be configured to detect a gaze cone corresponding to the detected gaze direction, which is a field of view within which the user may easily see without diverting their eyes or head from the detected gaze direction. The image/gaze detection-processing engine 123 can be configured to alternately estimate gaze direction by inputting images representing a photograph of a selected area near or around the eyes.

[0123] The one or more processors 114 may also generate commands or execute control operations based upon information received from a combination of the physical sensors 120, the

context sensors 121, the flexible display 104, the other components 124, and/or the other input devices. Alternatively, the one or more processors 114 can generate commands or execute control operations based upon information received from the one or more sensors or the flexible display 104 alone. Moreover, the one or more processors 114 may process the received information alone or in combination with other data, such as the information stored in the memory 115.

[0124] Other components 124 operable with the one or more processors 114 can include output components such as video outputs, audio outputs, and/or mechanical outputs. Examples of output components include audio outputs such as speaker port, earpiece speaker, or other alarms and/or buzzers and/or a mechanical output component such as vibrating or motion-based mechanisms. Still other components will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0125] As noted above, in one or more embodiments a blade assembly 102 is coupled to the flexible display 104. In contrast to sliding devices that include multiple device housings, the electronic device 100 of FIG. 1 includes a single device housing 101 to which the blade assembly 102 is coupled. The blade assembly 102 is configured as a mechanical chassis that allows the flexible display 104 to translate along a translation surface defined by major and minor surfaces of the single device housing 101. In one or more embodiments, the blade assembly 102 also provides a mechanical support for portions 130 of the flexible display 104 that extend beyond the top edge 131 of the single device housing 101 when the blade assembly 102 and flexible display 104 are in the extended position shown in FIG. 1. When the display roller mechanism 105 actuates, it causes the blade assembly 102 and the flexible display 104 to translate 301 along the rear major surface 103, the bottom minor surface, and the front major surface between the extended position shown in FIG. 1, the retracted position shown in FIG. 3, and the peek position shown in FIG. 5.

[0126] The blade assembly 102 can include a blade substrate 125 that includes both flexible portions and rigid portions, and that is positioned between the flexible display 104 and the translation surface defined by the single device housing 101. The blade substrate 125 can also comprise a silicone border 127 that surrounds and protects the edges of the flexible display 104. In one or more embodiments, the blade substrate 125 comprises a steel backer plate with the silicone border 127 co-molded around the perimeter of the steel backer plate. In one or more embodiments, a low-friction dynamic bending laminate stack 128 and blade 126 are positioned between the blade assembly 102 and the translation surfaces defined by the single device housing 101.

[0127] In one or more embodiments, the blade substrate 125 is partially rigid and partially flexible. Illustrating by example, portions of the blade substrate 125 that slide along the major surfaces of the single device housing 101 are configured to be substantially rigid, while portions of the blade substrate 125 that pass around the minor surfaces of the single device housing 101 are configured to be flexible so that they can curl around those minor surfaces. In one or more embodiments, some portions of the blade substrate 125 abut the translation surfaces defined by the single device housing 101 while other portions abut the display roller mechanism 105, which is positioned at the bottom minor surface of the single device housing 101 in this illustrative embodiment.

[0128] In one or more embodiments, the blade 126 and the low-friction dynamic bending laminate stack 128 are positioned between the blade assembly 102 and the translation surfaces defined by the single device housing 101. The blade 126 supports portions of the blade assembly 102 and flexible display 104 that extend beyond the top edge 131 of the single device housing 101 when the blade assembly 102 is transitioned to the extended position shown in FIG. 1. Since this blade 126 needs to be rigid to support those portions of the blade assembly 102 and the flexible display 104, it is not able to bend around the display roller mechanism 105. To prevent

gaps or steps from occurring where the blade 126 terminates, in one or more embodiments a low-friction dynamic bending laminate stack 128 spans the remainder of the blade assembly 102 and abuts the transition surfaces defined by the single device housing 101.

[0129] The blade assembly 102 can be fixedly coupled to the flexible display 104 by an adhesive or other coupling mechanisms. Where the blade substrate 132 defines both rigid and flexible portions. The blade substrate 132 can define a first rigid section extending along the major surfaces of the single device housing 101 and a second flexible section extending configured to wrap around the minor surfaces of the single device housing 101 where the display roller mechanism 105 is positioned.

[0130] In one or more embodiments, the blade assembly 102 defines a mechanical assembly providing a slider framework that allows the flexible display 104 to move between the extended position of FIG. 1, the retracted position of FIG. 3, and the peek position of FIG. 5. Additionally, the slider framework of the blade assembly 102 can be moved quickly in a short back and forth oscillatory motion to deliver haptic feedback in response to touch input. As used herein, the term “framework” takes the ordinary English definition of a mechanical support structure supporting the other components coupled to the slider framework. These components can include the blade 126, the silicone border 127, and the low-friction dynamic bending laminate stack 128. Other components can be included as well. Illustrating by example, this can include electronic circuits for powering the flexible display 104. Moreover, the blade assembly can include a tensioner that ensures that the flexible display 104 remains flat against the single device housing 101 when translating.

[0131] In one or more embodiments, the display roller mechanism 105 that causes a first portion of the blade assembly 102 and the flexible display 104 display (shown on the rear side of the electronic device 100 in FIG. 1) and a second portion of the blade assembly 102 and the flexible display 104 (positioned on the front side of the electronic device 100 in FIG. 1) to slide

symmetrically in opposite directions along the translation surfaces defined by the single device housing 101.

[0132] Thus, the electronic device 100 of FIG. 1 includes a single device housing 101 with a flexible display 104 incorporated into a blade assembly 102. The blade assembly 102 is then coupled to a translation mechanism defined by the display roller mechanism 105 and situated within the single device housing 101. In the explanatory embodiment of FIG. 1, the display roller mechanism 105 is situated at the bottom edge of the single device housing 101.

[0133] In one or more embodiments, in response to actuation of a user interface component 110 such as a button, the translation mechanism defined by the display roller mechanism 105 is operable to transition the blade assembly 102 around the surfaces of the single device housing 101 between the extended position of FIG. 1 where the blade 126 of the blade assembly 102 extends distally from the single device housing 101, a retracted position (shown in FIG. 3) where the blade assembly 102 abuts the single device housing 101 with the flexible display 104 wrapping around the surfaces of the single device housing 101, and a “peek” position (shown in FIG. 5) where movement of the translation mechanism defined by the display roller mechanism 105 causes the blade assembly 102 to reveal an image capture device situated beneath the blade assembly 102 on the front of the single device housing 101.

[0134] In other embodiments, the one or more processors 114 and/or an artificial intelligence classifier automatically transitions the blade assembly 102 and the flexible display 104 to a predefined state as a function of content presentation. Embodiments of the disclosure contemplate that in such an electronic device 100, manual actuation of the user interface component 110 potentially delays the usability of the electronic device 100 in the new state due to the time taken to manually “inject” the trigger causing transition of the blade assembly 102 and flexible display 104 by requiring the actuation of the user interface component 110.

[0135] Accordingly, in one or more embodiments the one or more processors 114 cause the blade assembly 102 to transition toward the extended position when the one or more processors 114 identify content to be newly presented on the flexible display 104. Similarly, when new split-screen content is identified to be presented on the flexible display 104, the one or more processors 114 can cause the blade assembly 102 to translate toward the extended position as well. When content – be it regular content or split-screen content – is removed from the flexible display 104, the one or more processors 114 can cause the blade assembly 102 to translate back toward the peek position.

[0136] In still other embodiments, the one or more processors 114 can, in response to the flexible display 104 detecting user input interacting with the flexible display, cause the translation mechanism 105 to move the blade assembly 102 with an oscillatory motion back and forth relative to a position of the blade assembly 102 relative to the device housing 101 to deliver haptic feedback when the user input occurs. If the position of the blade assembly 102 is the extended position described below with reference to FIG. 2 when the user input occurs, the oscillatory motion can initially move the blade assembly 102 toward the retracted position. If the position of the blade assembly 102 is the peek position revealing a front-facing imager described below with reference to FIG. 5 with the user input occurs, the oscillatory motion can initially move the blade assembly 102 toward the extended position.

[0137] In one or more embodiments, to deliver haptic feedback, the translation mechanism 105 causes the blade assembly 102 to move small amounts in a back-and-forth motion. Illustrating by example, in one or more embodiments the oscillatory motion translates the blade assembly 102 less than five millimeters in either direction when moving in the back-and-forth motion. In one or more embodiments, the oscillatory motion translates the blade assembly 102 back and forth only a predetermined number of times before ceasing, one example of which is five times.

[0138] Advantageously, embodiments of the disclosure provide an electronic device 100 that, when the flexible display 104 receives user input, delivers haptic feedback when a translation mechanism 105 causes a blade assembly 102 carrying the flexible display 104 to translate relative to the device housing 101 with an oscillatory motion. In one or more embodiments, this oscillatory motion is periodic. Illustrating by example, in one or more embodiments the oscillatory motion causes the blade assembly 102 to translate back and forth toward and away from the extended position and toward and away from the retracted position.

[0139] In one or more embodiments, this back-and-forth oscillatory motion only translates the blade assembly 102 within a predefined distance. Illustrating by example, in one or more embodiments the back-and-forth oscillatory motion translates the blade assembly 102 less than three millimeters.

[0140] In one or more embodiments, this back-and-forth oscillatory motion only translates the blade assembly 102 a predefined number of times. Illustrating by example, in one or more embodiments the back-and-forth oscillatory motion translates the blade assembly 102 less than five times.

[0141] In FIG. 1, the electronic device 100 includes a single device housing 101 with a blade assembly 102 coupled to two major surfaces of the single device housing 101 and wrapping around at least one minor surface of the electronic device 100 where the display roller mechanism 105 is situated. This allows the blade assembly 102 to slide relative to the single device housing 101 between a retracted position of FIG. 3, the extended position of FIG. 1, and the peek position of FIG. 5 revealing a front-facing image capture device.

[0142] It is to be understood that FIG. 1 is provided for illustrative purposes only and for illustrating components of one electronic device 100 in accordance with embodiments of the disclosure and is not intended to be a complete schematic diagram of the various components required for an electronic device. Therefore, other electronic devices in accordance with

embodiments of the disclosure may include various other components not shown in FIG. 1 or may include a combination of two or more components or a division of a particular component into two or more separate components, and still be within the scope of the present disclosure.

[0143] Turning now to FIG. 2, illustrated therein is the electronic device 100 in the extended position 200 that was also shown in FIG. 1. In the extended position 200, the blade (126) slides outward and away from the single device housing 101, thereby revealing more and more portions of the flexible display 104. In such a configuration, the portions of flexible display 104 passing around the display roller mechanism (105) elongated into a flat position as they pass along the translation surface defined by the front of the single device housing 101.

[0144] When user input is received while the blade assembly (102) is in the extended position 200 of FIG. 2, the back-and-forth oscillatory motion would initially translate the blade assembly (102) toward the retracted position of FIG. 3. This occurs because the blade assembly (102) is already maximally extended when the user input is received. Accordingly, the initial movement of the oscillatory motion would be toward the retracted position.

[0145] Turning now to FIGS. 3-4, illustrated therein is the electronic device 100 with the flexible display 104 in the retracted position 300. FIG. 3 illustrates the front side of the electronic device 100, while FIG. 4 illustrates the rear side.

[0146] In this state, blade (126) slides back toward, and then along, the translation surface defined by the single device housing 101. This causes the apparent overall length of the flexible display 104 to get shorter as more and more portions of the flexible display 104 pass around the display roller mechanism (105) positioned at the bottom of the single device housing 101 and across the translation surface defined by the rear side of the single device housing 101.

[0147] Turning now to FIG. 5, illustrated therein is the electronic device 100 with the flexible display in the peek position 500. When in the peek position, the blade assembly 102 and the flexible display 104 translate past the retracted position (300) of FIG. 3. In one or more

embodiments, when this occurs, the blade assembly 102 and the flexible display 104 reveal an image capture device 501 that is situated beneath the blade assembly 102 and the flexible display 104 when they are in the retracted position (300) of FIG. 3. In this illustrative embodiment, a loudspeaker 502 is also revealed.

[0148] When user input is received while the blade assembly (102) is in the peek position 500 of FIG. 5, the back-and-forth oscillatory motion would initially translate the blade assembly (102) toward the extended position (200) of FIG. 2. This occurs because the blade assembly (102) is already maximally retracted position when the user input is received. Accordingly, the initial movement of the oscillatory motion would be toward the extended position.

[0149] Advantageously, by positioning the image capture device 501 beneath the blade assembly 102 and the flexible display 104 when these components are in either the retracted position (300) of FIGS. 3-4 or the extended position (200) of FIG. 2, a user of the electronic device 100 is assured of privacy due to the fact that the image capture device 501 is not able to see through the blade (126) of the blade assembly 102. Accordingly, even if the electronic device 100 is accessed by a hacker or other nefarious actor, the user can be assured that the image capture device 501 cannot capture images or videos while the blade assembly 102 and flexible display 104 are in the retracted position (300), the extended position (200), or in positions therebetween. Only when the blade assembly 102 and the flexible display 104 transition to the peek position 500, thereby revealing the image capture device 501, can the image capture device 501 capture front-facing images or front-facing videos.

[0150] Referring collectively to FIGS. 2-5, it can be seen that the electronic device 100 includes a single device housing with a flexible display 104 incorporated into a blade assembly 102. The blade assembly 102 is coupled to a translation mechanism situated within the single device housing 101.

[0151] In response to actuation of a user interface device, one example of which is a button positioned on a side of the single device housing 101, or alternatively automatically, the translation mechanism is operable to transition the blade assembly 102 around the surfaces of the single device housing 101 between the extended position 200 where the blade (126) of the blade assembly 102 extends distally from the single device housing 101, the retracted position 300 where the blade assembly 102 abuts the single device housing 101 with the flexible display 104 and blade assembly 102 wrapping around the surfaces of the single device housing 101, and even positions therebetween, as a function of content that is to be newly presented on the flexible display 104.

[0152] While this can be done in response to actuation of user controls, to present additional (or less) content, to accommodate different aspect ratios for the presentation of content, or for other reasons, in one or more embodiments it is done to provide haptic feedback to a user. Illustrating by example, when one or more processors (114) of the electronic device 100 detect touch input interacting with the flexible display 104, the one or more processors (114) can cause the translation mechanism (105) to translate the flexible display 104 with a back and forth motion moving the flexible display 104 between the peek position 500 of FIG. 5 and the extended position 200 of FIG. 2 by an amount necessary to provide a haptic response to the touch input. In one or more embodiments, this amount necessary to provide the haptic response is less than three millimeters. In one or more embodiments, the back-and-forth motion lasts for less than three seconds. The oscillatory motion with which the flexible display 104 moves can be configured differently in different circumstances as well. For instance, the back-and-forth motion can be of a first type when the touch input interacts with a user actuation target and of a second type that is different from the first type when the touch input fails to interact with a user actuation target and so forth.

[0153] Another feature that can be seen in reviewing FIGS. 2-5 collectively is the how the presentation of content changes as a function of the position of the blade assembly 102. Embodiments of the disclosure contemplate that the position of the blade assembly 102 and flexible display 104 relative to the single device housing 101 change the amount of the flexible display 104 that is visible from the front, visible from the rear, and visible in the curved end portions. Said differently, the viewable size of the flexible display 104 from each side of the electronic device 100 will vary as a function of the position of the blade assembly 102 relative to the single device housing 101. Advantageously, embodiments of the disclosure provide applications, methods, and systems that dynamically resize and adjust the interface layouts and content presentations, as shown in FIGS. 2-5.

[0154] This can be accomplished by resizing a primary visible portion, e.g., the front-facing portion shown in FIGS. 2, 3, and 5, of the flexible display 104. Applications can be windowed on this primary area of the flexible display 104, which will resize as the flexible display 104 as it transitions between the extended position 200 of FIG. 2, the retracted position 300 of FIGS. 3-4, and the peek position 500 of FIG. 5.

[0155] In FIGS. 2-5, the one or more processors (114) of the electronic device 100 segment the flexible display 104 into three, individual, usable parts. These include the front-facing portion of the flexible display 104 shown in FIGS. 2, 3, and 5, the rear-facing portion of the flexible display 104 shown in FIG. 5, and the curvilinear portion of the flexible display 104 situated at the bottom of the electronic device 100 and wrapping around the rotor, shown in FIGS. 2-5. This curvilinear portion of the flexible display 104 is sometimes referred to as the “roll edge” portion of the display.

[0156] In one or more embodiments, each of these usable parts are dynamically remapped as the flexible display 104 changes position relative to the single device housing 101. In one or more

embodiments, applications can request windows on the usable portion upon which it intends to present content.

[0157] In one or more embodiments, the orientation of the rear-facing portion and the roll edge portion is not the same as that of the front-facing portion when the flexible display 104 translates along the single device housing 101 from the extended position 200 shown in FIG. 2 to the retracted position 300 shown in FIGS. 3-4 or the peek position 500 of FIG. 5. To address this, as can be seen by comparing FIGS. 3-4, in one or more embodiments content presented on the rear-facing portion is rotated by 180-degrees so that its “up” side is the same as the “up” side on the front-facing portion.

[0158] In one or more embodiments, the orientation of content presented on the roll edge portion can change based upon the orientation of the electronic device 100. If, for example, the front-facing side is up the orientation of content presented on the roll edge will have a first orientation. By contrast, if the rear-facing side is up, the orientation of that same content presented on the roll edge will have a second orientation that is rotated 180-degrees relative to the first orientation.

[0159] In one or more embodiments, any content presented on the front-facing portion of the flexible display 104 is oriented in accordance with user preferences. In one or more embodiments, this front-facing portion is oriented in accordance with the orientation of the electronic device 100 in three-dimensional space.

[0160] On the roll edge portion of the translating display, in one or more embodiments this segment is oriented in the same orientation as the front-facing portion when the electronic device 100 is not oriented with the front-facing side facing the negative z-direction in three-dimensional space (it is rotated by 180-degrees when this is the case). In one or more embodiments, the roll edge portion does not obey user preferences for display orientation and auto rotate/device orientation.

[0161] In one or more embodiments, content presented on the rear-facing portion of the flexible display 104 is always rotated by 180-degrees relative to content presented on the front-facing portion when the electronic device 100 is being held vertically, as is the case, and as can be seen, in FIGS. 3-4. In one or more embodiments, the rear-facing portion does not obey user preferences for display orientation and auto-rotate/device orientation.

[0162] Accordingly, in one or more embodiments one or more processors (114) of the electronic device (100) dynamically remap multiple translating display root segments based upon the position of the flexible display 104 relative to the single device housing 101. The one or more processors 114 can independently manage orientation and rotation on each of the root segments of the flexible display 104, be they the front-facing portion, the rear-facing portion, or the roll edge portion. In one or more embodiments, this management occurs independently based upon which side of the electronic device 100 the segment is currently positioned upon, combined with sensor inputs to identify if the electronic device 100 is face down or face up.

[0163] As shown in FIG. 2, the blade assembly 102 is operable to slide around the single device housing 101 such that the blade 126 slides away from the single device housing 101 to change an overall length of the flexible display 104 as viewed from the front of the electronic device 100. As shown in FIGS. 3-4, the blade assembly 102 can slide in an opposite direction around the single device housing 101 to a retracted position 300 with similar amounts of the flexible display 104 being visible on the front side of the electronic device 100 and the rear side of the electronic device 100.

[0164] Accordingly, in one or more embodiments the electronic device 100 includes a single device housing 101 with a blade assembly 102 coupled to two major surfaces of the single device housing 101 and wrapping around at least one minor surface of the electronic device 100 such that the blade assembly 102 can slide relative to the single device housing 101 between the

retracted position 300, the extended position 200, and the peek position 500 revealing a front-facing image capture device 501.

[0165] Turning now to FIG. 8, illustrated therein is the flexible display 104 shown in an exploded view, along with the blade assembly 102. As shown in FIG. 8, in one or more embodiments the flexible display 104 comprises one or more layers that are coupled or laminated together to complete the flexible display 104. In one or more embodiments, these layers comprise a flexible protective cover 801, a first adhesive layer 802, a flexible display layer 803, a second adhesive layer 804, and a flexible substrate 805. Other configurations of layers suitable for manufacturing the flexible display 104 will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0166] Beginning from the top of the layer stack, in one or more embodiments the flexible protective cover 801 comprises an optically transparent substrate. In one or more embodiments the flexible protective cover 801 may be manufactured from an optically transparent material such a thin film sheet of a thermoplastic material. Illustrating by example, in one embodiment the flexible protective cover 801 is manufactured from a layer of optically transparent polyamide having a thickness of about eighty microns. In another embodiment, the flexible protective cover 801 is manufactured from a layer of optically transparent polycarbonate having a thickness of about eighty microns. Other materials suitable for manufacturing the flexible protective cover 801 will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0167] In one or more embodiments the flexible protective cover 801 functions as a fascia by defining a cover for the flexible display layer 803. In one or more embodiments the flexible protective cover 801 is optically transparent, in that light can pass through the flexible protective cover 801 so that objects behind the flexible protective cover 801 can be distinctly seen. The flexible protective cover 801 may optionally include an ultra-violet barrier. Such a barrier can be useful in improving the visibility of flexible display layer 803 in one or more embodiments.

[0168] Beneath the flexible protective cover 801 is a first adhesive layer 802. In one or more embodiments, the first adhesive layer 802 comprises an optically transparent adhesive. The optically transparent adhesive can be applied to two sides of a thin, optically transparent substrate such that the first adhesive layer 802 functions as an optically transparent layer having optically transparent adhesive on both sides. Where so configured, in one or more embodiments the first adhesive layer 802 has a thickness of about fifty microns. This optically transparent version of “double-sided tape” can then be spooled and applied between the flexible protective cover 801 and the flexible display layer 803 to couple the two together.

[0169] In other embodiments the first adhesive layer 802 will instead be applied between the flexible protective cover 801 and the flexible display layer 803 as an optically transparent liquid, gel, as a homogeneous adhesive layer, or in the form of another medium. Where so configured, the first adhesive layer 802 can optionally be cured by heat, ultraviolet light, or other techniques. Other examples of materials suitable for use as the first adhesive layer 802 will be obvious to those of ordinary skill in the art having the benefit of this disclosure. In one or more embodiments, the first adhesive layer 802 mechanically couples the flexible display layer 803 to the flexible protective cover 801.

[0170] In one or more embodiments, the flexible display layer 803 is situated between the flexible substrate 805 and the flexible protective cover 801. In one or more embodiments, the flexible display layer 803 is longer along a major axis 806 of the flexible display layer 803, and thus the flexible display 104 itself, than is the image producing portion 808 of the flexible display 104. For instance, as shown in FIG. 8 the flexible display layer 803 includes a T-shaped tongue 807 that extends beyond the image producing portion 808 of the flexible display layer 803. As will be shown in FIG. 10 below, in one or more embodiments electronic circuit components configured to operate the image producing portion 808 of the flexible display layer 803, connectors, and other components can be coupled to this T-shaped tongue 807 in one or more

embodiments. Thus, in this illustrative embodiment the T-shaped tongue 807 extends distally beyond terminal ends of the other layers of the flexible display 104. While the T-shaped tongue 807 is T-shaped in this illustrative embodiment, it can take other shapes as well as will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0171] The flexible display layer 803 can optionally be touch-sensitive. In one or more embodiments, the flexible display layer 803 is configured as an organic light emitting diode (OLED) display layer. When coupled to the flexible substrate 805, the flexible display layer 803 can bend in accordance with various bending radii. For example, some embodiments allow bending radii of between thirty and six hundred millimeters. Other substrates allow bending radii of around five millimeters to provide a display that is foldable through active bending. Other displays can be configured to accommodate both bends and folds.

[0172] In one or more embodiments the flexible display layer 803 may be formed from multiple layers of flexible material such as flexible sheets of polymer or other materials. Illustrating by example, the flexible display layer 803 can include a layer of optically pellucid electrical conductors, a polarizer layer, one or more optically transparent substrates, and layers of electronic control circuitry such as thin film transistors to actuate pixels and one or more capacitors for energy storage. In one or more embodiments, the flexible display layer 803 has a thickness of about 130 microns.

[0173] In one or more embodiments, to be touch sensitive the flexible display layer 803 includes a layer including one or more optically transparent electrodes. In one or more embodiments, the flexible display layer 803 includes an organic light emitting diode layer configured to images and other information to a user. The organic light emitting diode layer can include one or more pixel structures arranged in an array, with each pixel structure comprising a plurality of electroluminescent elements such as organic light emitting diodes. These various layers can be coupled to one or more optically transparent substrates of the flexible display layer 803. Other

layers suitable for inclusion with the flexible display layer 803 will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0174] In one or more embodiments, the flexible display layer 803 is coupled to a flexible substrate 805 by a second adhesive layer 804. In other embodiments, a layer above the flexible display layer 803 can be configured with enough stiffness to make the flexible substrate 805 unnecessary. For example, in an embodiment where the flexible protective cover 801 is configured with enough stiffness to provide sufficient protection for the flexible display 104 during bending, the flexible substrate 805 may be omitted.

[0175] In one or more embodiments, the flexible substrate 805 comprises a thin layer of steel. Illustrating by example, in one or more embodiments the flexible substrate 805 comprises a steel layer with a thickness of about thirty microns. While thin, flexible steel works well in practice, it will be obvious to those of ordinary skill in the art having the benefit of this disclosure that other materials can be used for the flexible substrate 805 as well. For instance, in another embodiment the flexible substrate 805 is manufactured from a thin layer of thermoplastic material.

[0176] In one or more embodiments, to simplify manufacture, the second adhesive layer 804 is identical to the first adhesive layer 802 and comprises an optically transparent adhesive. However, since the second adhesive layer 804 is coupled between the flexible display layer 803 and the flexible substrate 805, i.e., under the flexible display layer 803, an optically transparent adhesive is not a requirement. The second adhesive layer 804 could be partially optically transparent or not optically transparent at all in other embodiments.

[0177] Regardless of whether the second adhesive layer 804 is optically transparent, in one or more embodiments the adhesive of the second adhesive layer 804 is applied to two sides of a thin, flexible substrate. Where so configured, in one or more embodiments the second adhesive layer 804 has a thickness of about fifty microns. This extremely thin version of “double-sided tape” can

then be spooled and applied between the flexible display layer 803 and the flexible substrate 805 to couple the two together.

[0178] In other embodiments, as with the first adhesive layer 802, the second adhesive layer 804 will instead be applied between the flexible display layer 803 and the flexible substrate as a liquid, gel, as a homogeneous layer, or in the form of another medium. Where so configured, the second adhesive layer 804 can optionally be cured by heat, ultraviolet light, or other techniques. Other examples of materials suitable for use as the second adhesive layer 804 will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0179] In this illustrative embodiment, the flexible display 104 is supported by not only the flexible substrate 805, but by the blade assembly 102 as well. As previously described, in one or more embodiments the blade assembly 102 includes a blade substrate 125. In one or more embodiments, the blade substrate 125 comprises a layer of steel. In one or more embodiments, the blade substrate 125 is thicker than the flexible substrate 805. Illustrating by example, in one or more embodiments when the flexible substrate 805 comprises a steel layer with a thickness of about thirty microns, the blade substrate 125 comprises a layer of steel having a thickness of about one hundred microns.

[0180] In one or more embodiments, the blade substrate 125 comprises a rigid, substantially planar support layer. Illustrating by example, the blade substrate 125 can be manufactured from stainless steel in one or more embodiments. In another embodiment, the blade substrate 125 is manufactured from a thin, rigid thermoplastic sheet. Other materials can be used in manufacturing the blade substrate 125 as well. For example, the material nitinol, which is a nickel-titanium alloy, can be used to manufacture the blade substrate 125. Other rigid, substantially planar materials will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0181] Accordingly, the blade substrate 125 defines another mechanical support for the flexible display 104. In one or more embodiments, the blade substrate 125 is the stiffest layer of the

overall assembly of FIG. 8. In one or more embodiments the blade substrate 125 is manufactured from stainless steel with a thickness of about one hundred microns. In another embodiment, the blade substrate 125 is manufactured from a flexible plastic. Other materials from which the blade substrate 125 can be manufactured will be obvious to those of ordinary skill in the art having the benefit of this disclosure. For instance, in another embodiment the blade substrate 125 is manufactured from carbon fiber, and so forth. In one or more embodiments, the blade substrate 125 includes a reinforcing border comprising a thicker layer of material to further protect the flexible display 104 when the blade assembly 102 is in the extended position (200).

[0182] In one or more embodiments, the flexible substrate 805 is slightly longer along a major axis of the flexible substrate 805 than is the image producing portion 808 of the flexible display 104. Since the T-shaped tongue 807 is T-shaped, this allows one or more apertures 809 to be exposed on either side of the base of the T of the T-shaped tongue 807. As will be described in more detail below, this extra length along the major axis provided by the flexible substrate 805 allows one or more fasteners to rigidly couple the first end of the flexible substrate 805 to a tensioner.

[0183] Embodiments of the disclosure contemplate that some of the layers comprising the flexible display 104 are stiffer than others. Similarly, other layers of the flexible display 104 are softer than others. For example, where the flexible substrate 805 is manufactured from a metal, one example of which is stainless steel, this layer is stiffer than either the first adhesive layer 802 or the second adhesive layer 804. In one or more embodiments, the stainless steel is stiffer than the flexible display layer 803 as well. In one or more embodiments, the flexible substrate 805 is the stiffest layer in the flexible display 104 while the first adhesive layer and the second adhesive layer 804 are the softest layers of the flexible display 104. The flexible protective cover 801 and the flexible display layer 803 have a stiffness that falls between that of the flexible substrate 805 and the adhesive layers in one or more embodiments.

[0184] In one or more embodiments, the various layers of the flexible display 104 are laminated together in a substantially planar configuration. Said differently, in one or more embodiments the flexible substrate 805 is configured as a substantially planar substrate. The second adhesive layer 804 can be attached to this substantially planar substrate, with the flexible display layer 803 then attached to the second adhesive layer 804. The first adhesive layer 802 can be attached to the flexible display layer 803, with the flexible protective cover 801 attached to the first adhesive layer 802.

[0185] To ensure proper coupling, the resulting flexible display layer 803 can be cured, such as in an autoclave at a predefined temperature for a predefined duration. Where employed, such curing allows any air bubbles or other imperfections in the various layers to be corrected. In one or more embodiments, since the flexible substrate 805 is configured as a substantially planar substrate, the resulting flexible display 104 is substantially planar as well.

[0186] In one or more embodiments, the blade substrate 125 of the blade assembly 102 includes both a flexible portion 810 and a rigid portion 811. Since the blade substrate 125 is manufactured from a metal in one or more embodiments, one example of which is steel having a thickness of one hundred microns, the rigid portion 811 gets its rigidity from the material from which it is manufactured. If, for example, the blade substrate 125 were manufactured from a thermoplastic material, in one or more embodiments this thermoplastic material would have enough rigidity that the rigid portion 811 would be rigid. Since the rigid portion 811 only slides along flat major surfaces of the translation surfaces defined by the single device housing (101), it does not need to bend. Moreover, rigidity helps to protect portions of the flexible display 104 that extend beyond ends of the single device housing (101).

[0187] By contrast, the flexible portion 810 need to wrap around minor faces of the single device housing (101) where the display roller mechanism (105) is situated. Since the flexible portion 810 is manufactured from the same material as the rigid portion 811 when the blade substrate 125 is

manufactured as a single unitary part, in one or more embodiments it includes a plurality of apertures cut through the blade substrate 125 allowing the material to bend. Illustrating by example, in one or more embodiments where the blade substrate 125 is manufactured from steel, a plurality of chemically or laser etched apertures can allow the flexible portion 810 to tightly wrap around minor faces of the single device housing (101) where the display roller mechanism (105) is situated.

[0188] Thus, in one or more embodiments the blade substrate 125 is partially rigid and partially flexible. Portions of the blade substrate 125 that slide along the major surfaces of the single device housing (101) are configured to be substantially rigid, while portions of the blade substrate 125 that pass around the minor surfaces of the single device housing (101) are configured to be flexible so that they can curl around those minor surfaces.

[0189] In one or more embodiments, the blade assembly 102 also includes a silicone border 127 positioned around a perimeter of the blade substrate 125. In one or more embodiments, the silicone border 127 surrounds and protects the edges of the flexible display 104 when the flexible display 104 is attached to the blade substrate 125 of the blade assembly 102. In one or more embodiments, the silicone border 127 is co-molded around the perimeter of the blade substrate 125.

[0190] In one or more embodiments, the rigid portion 811 of the blade substrate 125 can define one or more apertures. These apertures can be used for a variety of purposes. Illustrating by example, some of the apertures can be used to rigidly fasten the blade assembly 102 to a translation mechanism, one example of which was the display roller mechanism (105) of FIG. 1. Additionally, some of the apertures can contain magnets. Hall-effect sensors positioned in the single device housing (101) to which the blade assembly 102 is coupled can then detect the positions of these magnets such that the one or more processors (114) can determine whether the

blade assembly 102 and flexible display 104 are in the extended position (200), the retracted position (300), the peek position (500), or somewhere in between.

[0191] In one or more embodiments, the flexible display 104 coupled to the blade substrate 125 of the blade assembly 102 within the confines of the silicone border 127. Illustrating by example, in one or more embodiments a first end of the flexible display 104 is adhesively coupled to the rigid portion 811 of the blade substrate 125 of the blade assembly 102. The other end of the flexible display 104 can then be rigidly coupled to a tensioner by passing fasteners through the apertures 809 of the flexible substrate.

[0192] Turning now to FIG. 9, illustrated therein is the blade substrate 125 and silicone border 127 shown in an exploded view. As shown, the silicone border 127 defines a singular, contiguous, unitary piece of silicone. In the illustrative embodiment of FIG. 9, the silicone border 127 surrounds three sides 901,902,903 of the blade substrate 125, and extends beyond minor side 904 to define a receiving recess 905 that can accommodate mechanical and electrical components such as electronic circuit components to power and control the flexible display (104) that will situate within the perimeter defined by the silicone border 127, a tensioner to keep the flexible display (104) flat across the flexible portion 810 of the blade substrate 125, flexible circuits, and other components.

[0193] In this illustrative embodiment, the portions 906,907,908 of the silicone border 127 extending beyond the minor side 904 of the blade substrate 125 surrounding the receiving recess 905 are thicker than are the other portions of the silicone border 127 that will surround the flexible display (104). This allows for components to be placed within the receiving recess 905.

[0194] Turning now to FIG. 10, illustrated therein is the flexible display 104 and the blade assembly 102 with the silicone border 127 over-molded on the blade substrate 125. As shown, the silicone border 127 surrounds three sides 901,902,903 of the blade substrate 125 and extends

beyond minor side 904 to define a receiving recess 905 that can accommodate mechanical and electrical components.

[0195] Electronic circuits 1001 operable to power and control the flexible display 104 have been coupled to the T-shaped tongue 807 of the flexible display layer (803). Additionally, a mechanical connector 1002 has been connected to the top of the T on the T-shaped tongue 807. In this illustrative embodiment, the flexible substrate 805 extends beyond a distal end of the flexible display layer (803) so that the apertures 809 defined therein can be coupled to a tensioner to ensure that the flexible display 104 stays flat around the flexible portion 810 of the blade substrate 125 when the flexible portion 810 of the blade substrate 125 passes around a rotor positioned at the end of a single device housing (101).

[0196] The blade assembly 102 can be fixedly coupled to the flexible display 104 in one or more embodiments. Illustrating by example, where the blade substrate 125 defines both a rigid portion 811 and a flexible portion 810, in one or more embodiments the flexible display 104 is coupled to the rigid portion 811 by an adhesive or other coupling mechanism. A tensioner can then be positioned in the receiving recess 905. In one or more embodiments, the tensioner rigidly couples with fasteners to the apertures 809 of the flexible substrate 805 to keep the flexible display 104 flat across the flexible portion 810, regardless of how the flexible portion 810 is being bent around the minor surface of a single device housing or its corresponding rotor.

[0197] Turning now to FIG. 11, illustrated therein is the flexible display 104 after being coupled to the blade assembly 102. As shown, the silicone border 127 surrounds the flexible display 104, with the silicone border 127 surrounding and abutting three sides of the flexible display layer (803).

[0198] A flexible substrate is then connected to the electronic circuits 1001 carried by the T-shaped tongue 807. Additionally, a tensioner can be coupled to the flexible substrate 805. Thereafter, a cover 1101 is attached to the silicone border 127 atop the electronic circuits 1001

and other components situated on or around the T-shaped tongue. This portion the blade assembly 102 where the components are stored beneath the cover 1101 is affectionately known as the “backpack.” Turning to FIG. 12, illustrated therein is the blade assembly 102 with its backpack 1201 completely configured.

[0199] In one or more embodiments, the flexible display 104 and blade assembly 102 are configured to wrap around a minor surface of a device housing where a display roller mechanism is situated. In one or more embodiments, the display roller mechanism includes a rotor that is positioned within a curvilinear section of the flexible display 104 and blade assembly 102. When placed within a device housing of an electronic device, translation of a translation mechanism causes translation of the blade assembly 102, which in turn causes rotation of the rotor. The result is a linear translation of the flexible display 104 and blade assembly 102 across a translation surface of the device housing by drawing the flexible display 104 and the blade assembly 102 around the rotor.

[0200] That the blade substrate (125) of the blade assembly 102 includes a flexible portion (810) allows the blade assembly 102 and flexible display 104 to deform around a device housing, one example of which is the single device housing (101) of FIG. 1. Illustrating by example, turning now to FIGS. 13-14, illustrated therein is the blade assembly 102 and flexible display deformed to create a curvilinear section 1301 and two linear sections 1302,1303. The flexible display 104 and blade assembly 102 are shown as they would be in the retracted position 300 in FIG. 13. The flexible display 104 and the blade assembly 102 are shown as they would be in the extended position 200 in FIG. 14. The enlarged view 1401 of FIG. 14 shows how the apertures defined by the chemical etching of the blade substrate 125 easily allow the blade substrate 125 to bend around the curvilinear section 1301 while maintaining a rigid support structure beneath the flexible display 104 in the two linear sections 1302,1303.

[0201] In one or more embodiments, the first linear section 1302 and the second linear section 1303 are configured to slide between the retracted position 300 of FIG. 13 and the extended position 200 of FIG. 14. The flexible display 104 is coupled to the blade assembly 102 and therefore translates with the blade assembly 102 along a translation surface defined by a device housing of an electronic device.

[0202] In one or more embodiments, the linear sections 1302,1303 of the blade assembly 102 are positioned between the flexible display 104 and the translation surface. A rotor is then positioned within a curvilinear section 1301 of the blade assembly 102. When a translation mechanism causes the linear sections 1302,1303 of the blade assembly 102 to move across the translation surface defined by the device housing, the rotor rotates with the flexible portion 810 passing along the rotor while the rotor rotates.

[0203] As shown in FIGS. 13-14, in one or more embodiments a cross section of both the blade assembly 102 and the flexible display 104 defines a J-shape with a curved portion of the J-shape, defined by the curvilinear section 1301, configured to wrap around a rotor and an upper portion of the J-shape, defined by linear section 1302, passing across a translation surface defined by a device housing. When the translators of a translation mechanism drive the blade assembly 102, the upper portion of the J-shape becomes longer as the flexible display 104 translates around the rotor with the blade assembly 102 extending further from of the device housing. This can be seen in FIGS. 13-14 by comparing the extended position 200 of FIG. 14 to the retracted position 300 of FIG. 13.

[0204] When the translators of the translation mechanism drive the blade assembly 102 in the opposite direction, e.g., driving the blade assembly 102 from the extended position 200 of FIG. 14 to the retracted position 300 of FIG. 13, the upper portion of the J-shape becomes shorter as the reverse operation occurs. Thus, when the translation mechanism drives the blade assembly

102 carrying the flexible display 104, the flexible display 104 deforms at different locations as it wraps and passes around the rotor.

[0205] It should be understood that a more traditional “J-shape” is principally defined when the blade assembly 102 is transitioned to the extended position 200 of FIG. 14. Depending upon the length of the blade assembly 102 and flexible display 104, combined with the amount the translation mechanism can cause the blade assembly 102 to slide around the rotor, the J-shape may transition to other shapes as well, including a U-shape where the upper and lower portions of the blade assembly 102 and/or flexible display 104 are substantially symmetrical. Such a U-shape forms when the blade assembly is in the peek position but is substantially formed in the retracted position 300 of FIG. 3. In other embodiments, depending upon construction, the blade assembly 102 may even transition to an inverted J-shape where the upper portion of the blade assembly 102 and/or flexible display 104 is shorter than the lower portion of the blade assembly 102 and/or flexible display 104, and so forth.

[0206] In one or more embodiments, the translators and rotor of the translation mechanism not only facilitate the “extension” of the flexible display 104 that occurs during an extending or “rising” operation, but also works to improve the reliability and usability of the flexible display 104 as well. This is true because the rotor defines a service loop 1304 in the curvilinear section 1301 with a relatively large radius compared to the minimum bending radius of the flexible display 104. The service loop 1304 prevents the flexible display 104 from being damaged or developing memory in the curved state occurring as the flexible display 104 defines the curvilinear section 1301 wrapping around the rotor in the extended position 200, retracted position 300, and peek position (500).

[0207] Using such a mechanical assembly, the flexible display 104 maintains a flat upper portion of the J-shape defined by the first linear section 1302 when sliding. Additionally, the flexible display 104 wraps tightly around the rotor with the lower portion of the J-shape defined by the

second linear section 1303 remaining flat against the lower surface of a device housing as well. The blade assembly 102 and tensioner combination, which are rigidly affixed to the translation mechanism, precludes the flexible display 104 from crumpling or bunching when sliding around the device housing between the extended position 200, the retracted position 300, and the peek position (500). This rigid coupling combined with moving tensioner ensures a straight and true translation of the flexible display 104 across a first major surface of an electronic device, around the rotor of the electronic device positioned at a minor surface of the device housing, and across a second major surface of the electronic device.

[0208] In one or more embodiments additional support components can be attached to the blade assembly 102 to one or more of provide additional support for the flexible display 104, ease translation of the blade assembly 102 around a device housing, or combinations thereof.

[0209] As noted above, in one or more embodiments a blade assembly 102 is coupled to the flexible display 104. In contrast to sliding devices that include multiple device housings, embodiments of the disclosure provide an electronic device with a sliding display that includes only on device housing. The blade assembly 102 is configured as a mechanical chassis that allows the flexible display 104 to translate along a translation surface defined by major and minor surfaces of the single device housing.

[0210] In one or more embodiments, the blade assembly 102 also provides a mechanical support for portions of the flexible display 104 that extend beyond the top edge of the single device housing when the blade assembly 102 and flexible display 104 are in the extended position. The blade assembly 102 can include a blade substrate (125) that is unitary, but that defines both flexible portions and rigid portions. The blade substrate (125) can comprise the silicone border 127 that surrounds and protects the edges of the flexible display 104.

[0211] A low-friction dynamic bending laminate stack (128) and blade (126) can be positioned between the blade assembly 102 and the translation surfaces defined by the single device housing

(101). In one or more embodiments, the blade (126) and the low-friction dynamic bending laminate stack (128) are positioned between the blade assembly 102 and the translation surfaces defined a device housing to which the blade assembly 102 is attached.

[0212] The blade (126) supports portions of the blade assembly 102 and flexible display 104 that extend beyond the top edge of the device housing when the blade assembly 102 is transitioned to the extended position. Since this blade (126) needs to be rigid to support those portions of the blade assembly 102 and the flexible display 104, it is not able to bend around the flexible portions of the blade substrate (125) of the blade assembly 102. To prevent gaps or steps from occurring where the blade (126) terminates, in one or more embodiments a low-friction dynamic bending laminate stack (128) spans the remainder of the blade assembly 102 and abuts the transition surfaces defined by the single device housing.

[0213] In one or more embodiments, the blade (126) comprises a layer of steel. In one or more embodiments, the blade (126) has a thickness that is greater than the thickness of either the blade substrate (125) of the blade assembly 102 or the flexible substrate (805) of the flexible display 104. Illustrating by example, in one or more embodiments the blade (126) comprises a layer of steel having a thickness of five hundred microns or 0.5 mils.

[0214] In one or more embodiments, the blade (126) comprises a rigid, substantially planar support layer. Illustrating by example, the blade (126) can be manufactured from aluminum, steel, or stainless steel in one or more embodiments. In another embodiment, the blade (126) is manufactured from a rigid thermoplastic sheet. Other materials can be used in manufacturing the blade substrate (125) as well. For example, nitinol can be used to manufacture the blade (126) as well.

[0215] In one or more embodiments, the blade (126) is the stiffest layer of the overall assembly. In one or more embodiments the blade (126) is manufactured from stainless steel with a thickness of about five hundred microns. In another embodiment, the blade (126) is manufactured from

carbon fiber. Other materials from which the blade (126) can be manufactured will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0216] In one or more embodiments, the low-friction dynamic bending laminate stack (128) comprises a plurality of layers. When assembled, the low-friction dynamic bending laminate stack (128) adds a layer to the blade assembly 102 that improves the lubricity of the overall assembly to allow for smooth motion of the blade assembly 102 and flexible display 104 across the translation surfaces of a device housing. Moreover, when abutting a blade (126), the low-friction dynamic bending laminate stack (128) prevents features on other layers of the assembly from degrading the ability of the blade assembly 102 and flexible display 104 to translate across those translation surfaces.

[0217] In one or more embodiments, the low-friction dynamic bending laminate stack (128) allows for “low-friction” sliding across a stationary surface combined with the ability to cyclically bend and/or roll around a rotor. In one or more embodiments, the low-friction dynamic bending laminate stack (128) interfaces and abuts the blade (126) to improve lubricity.

[0218] In one or more embodiments, the uppermost layer of the low-friction dynamic bending laminate stack (128) is a pressure sensitive adhesive layer. This pressure sensitive adhesive layer allows the low-friction dynamic bending laminate stack (128) to adhere to the underside of the blade assembly 102.

[0219] Beneath this pressure sensitive adhesive layer is a strain tolerant foam layer in one or more embodiments. Examples of strain tolerant foams suitable for use as the strain tolerant foam layer include silicone, low-density polyethylene, or other materials that provide sufficient thickness so as to allow the low-friction dynamic bending laminate stack (128) to match the thickness of the blade (126) while reducing internal stresses and allowing bending.

[0220] Beneath the strain tolerant foam layer is another pressure sensitive adhesive layer in one or more embodiments. This pressure sensitive adhesive layer couples a flexible substrate having a

strain relief cutout pattern formed therein. The flexible substrate can be manufactured from metal or plastic or other materials. Illustrating by example, in one or more embodiments the flexible substrate comprises a steel layer with a thickness of about thirty microns. While thin, flexible steel works well in practice, it will be obvious to those of ordinary skill in the art having the benefit of this disclosure that other materials can be used for the flexible substrate as well. For instance, in another embodiment the flexible substrate is manufactured from a thin layer of thermoplastic material.

[0221] Another layer of pressure sensitive adhesive then couples the flexible substrate to a low-friction layer in one or more embodiments. In one or more embodiments, the low-friction layer comprises a substrate with Teflon^{sup}.TM attached thereto. In another embodiment, the low-friction layer comprises a layer of polytetrafluoroethylene, which is a synthetic fluoropolymer of tetrafluoroethylene. This material is best known for its non-stick properties and adds a lubricity to the low-friction dynamic bending laminate stack (128) that allows the overall assembly to slide smoothly. Moreover, the low-friction layer prevents the strain relief cutout pattern in the flexible substrate from snagging on surface imperfections and transitions on the device housing to which the assembly is attached. In short, the low-friction layer greatly improves the lubricity of the overall assembly.

[0222] FIGS. 15-20 illustrate the electronic device 100 of FIG. 1 as fully assembled in both the extended position 200 and retracted position 300. Embodiments of the disclosure contemplate that in addition to having distinctly unique utilitarian features, electronic devices configured in accordance with embodiments of the disclosure have distinctly unique ornamental features as well. Many of these ornamental features are visible in FIGS. 15-20.

[0223] FIG. 15 illustrates a front elevation view of the electronic device 100 in the extended position 200, while FIG. 16 illustrates a side elevation view of the electronic device 100 in the

extended position 200. FIG. 17 then provides a rear elevation view of the electronic device 100 in the extended position 200 as well.

[0224] FIG. 18 illustrates a front elevation view of the electronic device 100 in the retracted position 300, while FIG. 19 illustrates a side elevation view of the electronic device 100 in the retracted position 300. FIG. 20 then provides a rear elevation view of the electronic device 100 in the retracted position 300.

[0225] As can be seen by comparing these figures, the blade assembly 102 is able to slide around the single device housing 101 such that the blade 126 slides away from the single device housing 101 to change the apparent overall length of the flexible display 104 as viewed from the front of the electronic device 100. The blade assembly 102 can also slide in an opposite direction around the single device housing 101 to the retracted position 300, where similar amounts of the flexible display 104 are visible on the front side of the electronic device 100 and the rear side of the electronic device 100. Graphics, images, user actuation targets, and other indicia can be presented anywhere on the flexible display 104, including on the front side of the electronic device 100, the rear side of the electronic device 100, or the lower end of the electronic device 100.

[0226] While much attention to this point has been paid to the unique translation of the blade assembly and flexible display between the extended position and the retracted position, one of the other truly unique features offered by embodiments of the disclosure occur when the blade assembly and flexible display transition to the peek position. Turning now to FIGS. 21-22, illustrated therein is the electronic device 100 in this peek position 500.

[0227] As shown in FIG. 21, in one or more embodiments when the blade assembly 102 and flexible display 104 transition to the peek position 500, the backpack 1201 moves toward beyond the retracted position (300) toward the rear-facing image capture devices 108. When this occurs, an upper edge 2101 of the blade assembly 102 moves below an upper edge 2102 of the single device housing 101. In one or more embodiments, this reveals a front-facing image capture

device 501 that situates beneath the blade assembly 102 when the blade assembly 102 is in the retracted position (300).

[0228] In one or more embodiments, the translation of the blade assembly 102 and flexible display 104 to the peek position 500 occurs automatically. Illustrating by example, in one or more embodiments when the front-facing image capture device 501 is actuated, the one or more processors (114) of the electronic device 100 cause the blade assembly 102 to translate to the peek position 500, thereby revealing this image capture device 501. (In the explanatory embodiment of FIGS. 21-22, a loudspeaker 502 is also revealed.) Once image capture operations utilizing the image capture device 501 are complete, the one or more processors (114) can cause the blade assembly 102 to transition back to the retracted position, which again covers and occludes the image capture device 501.

[0229] In other embodiments, the transition to the peek position 500 is manually initiated through actuation of a button or other user interface control. Illustrating by example, a single press of the button 2103 might cause the blade assembly 102 to transition to the extended position (200), while a double press of the button 2103 causes the blade assembly 102 to return to the retracted position (300). A long press of the button 2103 may cause the blade assembly 102 to transition to the peek position 500 of FIG. 5, and so forth. Other button operation schema will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0230] By positioning the front-facing image capture device 501 beneath the blade assembly 102 and its corresponding opaque blade (126) when in normal operation, embodiments of the disclosure provide a privacy guarantee to users of the electronic device 100. Said differently, by positioning the image capture device 501 beneath the blade assembly 102 and the flexible display 104 when these components are in either the retracted position (300) or the extended position (200), a user of the electronic device 100 is mechanically assured of privacy due to the fact that it

is physically impossible for the image capture device 501 to perform image capture operations through the blade (126) of the blade assembly 102.

[0231] Accordingly, even if the electronic device 100 is accessed by a hacker or other nefarious actor, the user can be assured that the image capture device 501 cannot capture images or videos while the blade assembly 102 and flexible display 104 are in the retracted position (300), the extended position (200), or in positions therebetween. Only when the blade assembly 102 and the flexible display 104 transition to the peek position 500, thereby revealing the image capture device 501, can the image capture device 501 capture front-facing images or front-facing videos.

[0232] While the blade assembly (102) carrying the flexible display 104 can be transitioned to the extended position 200, the retracted position 300, or the peek position 500 for a variety of reasons, such as to increase the front-facing portions of the flexible display 104 when additional content needs to be presented or reducing the front-facing portions of the flexible display 104 when content is consumed, in one or more embodiments movement of the blade assembly (102) occurs to deliver haptic feedback to a user in response to user input interacting with the flexible display 104. Turning now to FIGS. 23-26, attention will be directed to this haptic feedback method since the content presentation and other reasons for moving the blade assembly (102) and flexible display 104 have been sufficiently described above.

[0233] Beginning with FIG. 23, illustrated therein is one explanatory method 2300 in accordance with one or more embodiments of the disclosure. The method 2300 of FIG. 23 is intended for use in an electronic device having a device housing, a blade assembly carrying a blade and a flexible display, with the blade assembly being slidably coupled to the device housing, a translation mechanism operable to slide the blade assembly relative to the device housing between at least an extended position and a retracted position, and one or more processors operable with the translation mechanism.

[0234] The method 2300 of FIG. 23 solves problems arising in situations where it is desirable to provide haptic feedback to a user using only the blade assembly and flexible display. The method 2300 of FIG. 23 therefore eliminates the need for other haptic feedback devices, e.g., motors, buzzers, thumpers, piezoelectric transducers, or other such devices capable of delivering haptic feedback to be included with the electronic device. At the same time, the method 2300 of FIG. 23 can be used to complement the usage of conventional haptic feedback transducers as well.

[0235] Advantageously, the method 2300 of FIG. 23 comprises receiving, by a flexible display carried by a blade assembly that is slidably coupled to a device housing and moveable between at least an extended position and a retracted position, flexible input and delivering, by a translation mechanism in response to the user input, haptic feedback by moving the blade assembly carrying the flexible display. In one or more embodiments, this movement occurs in a short, fast, oscillatory motion relative to the device housing to which the blade assembly carrying the flexible display is attached.

[0236] Illustrating by example, in one or more embodiments the blade assembly can be moved in an oscillatory motion that is periodic. The oscillatory motion may cause the blade assembly to translate back and forth toward, and away from, the extended position, and toward, and away from, the retracted position. This oscillatory motion may cause the blade assembly to make such movements within a predefined distance, one example of which is less than three millimeters. This oscillatory motion may also cause the blade assembly to make such movements less than a predetermined number of times, one example of which is less than five times.

[0237] If the blade assembly is already at the extended position when the user input is received, the oscillatory motion may initially cause the blade assembly to translate toward the retracted position, i.e., between the extended position and another position situated closer to the retracted position. Once again, this motion can occur within a predefined distance for a predefined number of times.

[0238] Where the blade assembly is translatable to a peek position revealing a front-facing imager, and when the blade assembly is in the peek position when the user input is received, the oscillatory motion may cause the blade assembly to translate initially toward the extended position, i.e., between the peek position and another position that is situated closer to the extended position. As before, this motion can occur within a predefined distance and for a predefined number of times.

[0239] The nature of the oscillatory motion can change based upon context. Illustrating by example, the motion can occur in accordance with a first oscillatory motion pattern when the user input occurs at a location corresponding to a user actuation target presented on the flexible display, examples of which were shown on the front-facing portion of the flexible display (104) of FIG. 1. Similarly, the oscillatory motion can occur in accordance with a second oscillatory motion pattern that is different from the first oscillatory motion pattern when the user input occurs at another location failing to correspond to the user actuation target presented on the flexible display, and so forth.

[0240] In effect, the method 2300 of FIG. 23 detects, optionally with one or more processors in an electronic device, touch input interacting with a flexible display carried by a blade assembly that is slidably coupled to a device housing and moveable between an extended position, a retracted position, and optionally a peek position. In response to touch input, the method 2300 translates, optionally with a translation mechanism operable with the one or more processors, the blade assembly with a back-and-forth motion moving the blade assembly between the retracted position or peek position and the extended position by an amount necessary to provide a haptic response to the touch input. One example of such an amount is less than three millimeters, although other amounts will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0241] The method 2300 can be used when the electronic device is in an unlocked operating condition in one or more embodiments. Illustrating by example, if a user is employing an electronic device to read email, the method 2300 may provide the haptic response when the user selects an email to read. The method 2300 of FIG. 23 can also be used when the electronic device is in a locked state. Illustrating by example, when a user wakes the device to enter a passcode or request biometric authentication, the blade assembly may move in the back-and-forth motion to deliver haptic feedback as well. These examples are illustrative only, as numerous others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0242] While primary embodiments of the method 2300 of FIG. 23 are to provide haptic feedback in response to user input, other actions can trigger the delivery of haptic feedback by moving the flexible display in an oscillatory motion as well. Consider the situation where an electronic device is in either a locked state or an unlocked state and a message or notification is received. In one or more embodiments, this can cause a translation mechanism to translate a blade assembly with a back-and-forth motion moving the blade assembly slightly back and forth to deliver haptic feedback in response to the message or notification.

[0243] Combinations of content-based translation and haptic feedback translation can occur as well. Illustrating by example, when the electronic device is in a locked state, if there are no pending notifications, the one or more processors of the electronic device can cause the translation mechanism to translate the blade assembly to the retracted position. However, as content to be newly presented on the front-facing portion of the flexible display is received, e.g., notifications, reminders, messages, and so forth, the one or more processors can cause the translation mechanism to initially move the blade assembly with the back and forth motion in an amount necessary to provide haptic feedback, thereafter translating the blade assembly toward the extended position so that there is sufficient real estate on the front-facing portion of the flexible display to present this newly arriving content. This results movement of the flexible display

delivering both a haptic response to the user and then revealing an additional area amount of the front-facing portion of the flexible display to present new content. Once the notifications are consumed, deleted, or otherwise removed from the front-facing portion of the flexible display, a haptic response can indicate such consumption, deletion or removal with the translation mechanism thereafter translating the blade assembly back toward the retracted position to remove unnecessary front-facing portions of the flexible display.

[0244] Beginning with step 2301, the method 2300 comprises presenting content, user interface controls, application portals, and/or user actuation targets on a user interface of an electronic device, one example of which is the flexible display (104) of FIG. 1. The content can comprise images, videos, text, user interface portals, websites, documents, or other content that one would normally see when consuming or creating content using a portable electronic device. The user actuation target may be configured as icons or other interactive content element that, when interacted with by a user, cause operations to occur such as opening programs, changing pages or views, launching features, and so forth.

[0245] Decision 2302 then determines whether a flexible display carried by a blade assembly that is slidably coupled to a device housing and moveable between an extended position and a retracted position receives user input interacting with the content, user interface controls, application portals, and/or user actuation targets. Where such user input is received, the method 2300 moves to decision 2303. Otherwise, the method 2300 moves to step 2309 where the position of the flexible display, as determined by the location of the blade assembly relative to the device housing, remains unchanged.

[0246] Where decision 2302 determines that user input is received by the flexible display carried by the blade assembly that is slidably coupled to a device housing and moveable between the extended position and the retracted position, the method 2300 delivers, by a translation mechanism in response to the user input, haptic feedback by causing the blade assembly to

translate relative to the device housing. This translation can be with an oscillatory motion and causes the flexible display to move with an oscillatory back and forth motion by an amount required to deliver a haptic response to a user. Exactly how this occurs depends upon the position the blade assembly is in relative to the device housing when the user input is received.

[0247] Illustrating by example, if the blade assembly is in the extended position when the user input is received, its distal end cannot extend further away from the device housing. Accordingly, any oscillatory back and forth motion must initially cause the flexible display to transition toward the retracted position or the peek position. As such, decision 2303 determines whether the blade assembly is at the extended position when the user input is received. Where it is, step 2307 comprises delivering, by a translation mechanism in response to the user input, haptic feedback by causing the blade assembly to translate relative to the device housing with an oscillatory motion by causing the blade assembly to translate between the extended position and another position closer to the retracted position or peek position at step 2308.

[0248] This oscillatory motion occurring at step 2308, as well as that occurring at step 2305 and step 2307, can occur in different ways. Illustrating by example, in one or more embodiments the oscillatory motion is periodic and causes the blade assembly to translate back and forth between the extended position and the retracted position or peek position. This oscillatory motion can cause such a motion between the extended position and the retracted position or peek position to occur within a predefined distance. One example of such a predefined distance is one that is less than three millimeters. In another embodiment, the oscillatory motion translates the blade assembly back and forth within a total distance that is less than five millimeters. These examples are illustrative only, as others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0249] In one or more embodiments, the oscillatory motion delivering haptic feedback at step 2305, step 2307, and/or step 2308 causes the blade assembly to translate back and forth toward

the extended position and toward the retracted position or peek position a predefined number of times. Illustrating by example, the oscillatory motion may cause the blade assembly to translate back and forth toward the extended position and toward the retracted position or peek position less than five times in one or more embodiments. In other embodiments, the oscillatory motion may cause the blade assembly to translate back and forth between the extended position and the retracted position or peek position less than seven times. These number of “jiggles” of the flexible display carried by the blade assembly to deliver the haptic feedback are illustrative only, as numerous others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0250] Where decision 2303 determines that the blade assembly is in the extended position when the user interface is received, at step 2308 the oscillatory motion causes the blade assembly to translate between the extended position and another position closer to the retracted position. In one or more embodiments, this translation occurring at step 2308 occurs within a predefined distance and for a predefined number of times sufficient to provide the haptic feedback.

[0251] Thereafter, decision 2306 determines whether this predefined number of times and other characteristics of the oscillatory motion required to deliver the haptic feedback is complete. Where it is, the oscillatory motion ceases until additional user interface requiring the delivery of haptic feedback is received as determined again by decision 2302. Otherwise the oscillatory motion can continue until the predefined number of cycles of the oscillatory motion is completed.

[0252] Just as the blade assembly is unable to extend further when in the extended position, when in the peek position it is unable to retract further. Accordingly, decision 2304 determines whether the blade assembly is in the peek position when the user interface is received. Where it is, further movement reducing front-facing portions of the flexible display is unavailable. Accordingly, step 2307 comprises moving the blade assembly with an oscillatory motion that causes the blade assembly to translate between the peek position and another position closer to

the extended position. As before, this oscillatory motion can be periodic, can occur within a predefined distance, and can occur for a predefined number of times.

[0253] If the blade assembly is not in either of the extended position or the peek position, it is free to travel back and forth relative to its position when the user input was received. Accordingly, step 2305 comprises delivering, by a translation mechanism in response to the user input, haptic feedback by causing the blade assembly to translate relative to the device housing with an oscillatory motion. As previously described, this oscillatory motion can be periodic, can occur within a predefined distance, and can occur for a predefined number of times.

[0254] Embodiments of the disclosure contemplate that the motion created to deliver the haptic feedback can occur in accordance with different characteristics, patterns, distances, frequencies, numbers of times, or combinations thereof to deliver different types of haptic feedback in different conditions. Illustrating by example, if a message is received, one type of haptic feedback may occur. By contrast, if a notification is received or generated by an application, another type of haptic feedback may be delivered.

[0255] Embodiments of the disclosure also contemplate that one of the main reasons haptic feedback is useful in practice is confirming to a user that a particular user actuation target has been successfully touched. Illustrating by example, if a telephone number pad is presented as a plurality of user actuation targets on the display of an electronic device, a person may have a specific desire to know whether they hit a number user actuation target or missed it. Accordingly, in one or more embodiments the haptic feedback delivered – which can be delivered at any of step 2305, step 2307, or step 2308 – can occur as a function of whether the user input successfully interacted with a user actuation target.

[0256] In one or more embodiments, the oscillatory motion delivered at any of step 2305, step 2307, or step 2308 can comprise the blade assembly moving with an oscillatory motion that occurs with a predefined pattern when the user input occurs at a location corresponding to a user

actuation target presented on the flexible display. However, the oscillatory motion can occur with another predefined oscillatory pattern that is different from the predefined oscillatory pattern when the user input occurs at another location failing to correspond with a user actuation target presented on the flexible display. Advantageously, this lets the user know whether they successfully interacted with a user actuation target or missed the same. Some examples of how this might occur are shown in FIG. 24.

[0257] Turning now to FIG. 24, illustrated therein is a step, which could be any of step (2305), step (2307), or step (2308), occurs in accordance with different patterns. As shown in FIG. 24, the oscillatory motion delivering the haptic feedback may occur in accordance with a first pattern 2401 when a phone call is received, while the oscillatory motion delivering the haptic feedback occurs in accordance with a second pattern 2402 that is different from the first pattern 2401. As used herein, “pattern” refers to frequency, number of cycles, distance, velocity, shape of motion, symmetry of motion, and/or duration with which a blade assembly carrying a flexible display moves relative to the device housing. Thus, the first pattern 2401 may simply “wiggle” the flexible display faster than the second pattern 2402 in one or more embodiments. In other embodiments, the differences may be more complex, with the first pattern 2401 moving the blade assembly a first distance at a first frequency using a symmetric triangular waveform while the second pattern 2402 moves the blade assembly a second distance at a second frequency in accordance with an asymmetric square wave, and so forth.

[0258] In similar fashion, when a user actuation target is actuated the oscillatory motion delivering the haptic feedback can be in accordance with a third pattern 2403 when the user input interacts with a user actuation target, while a fourth pattern 2405 that is different from the third pattern 2403 is used if the user input misses the user actuation target. A fifth pattern 2404 can be used when a notification is received from an application operating on one or more processors of the electronic device, while a different, sixth pattern 2406 is used for a system notification, such

as one requiring an update of an operating system. Since the combinations of frequency, number of cycles, distance, velocity, shape of motion, symmetry of motion, and/or duration with which a blade assembly carrying a flexible display moves relative to the device housing is almost limitless, any number of patterns 2407 can be selected to correspond to selected types of user input, content that is presented, information that is received or generated, and so forth.

[0259] To illustrate the method (2300) of FIG. 23 in more detail, FIG. 25 illustrates one or more method steps highlighting one use case where embodiments of the disclosure are beneficial. Numerous others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0260] Beginning at step 2501, a user 2506 is holding an electronic device 100 configured as described above with reference to FIGS. 1-22. The electronic device 100 comprises a device housing 101, a blade assembly 102 carrying a blade and a flexible display 104. The blade assembly is slidably coupled to the device housing 101 and is movable between an extended position, a retracted position, and a peek position. As previously described, a translation mechanism (105) is operable to slide the blade assembly 102 relative to the device housing 101 between the extended position, the retracted position, and the peek position. In this illustrative embodiment, translating the blade assembly 102 to the peek position reveals a front-facing imager (502). Additionally, one or more processors (114) are operable with the flexible display 104 and the translation mechanism (105).

[0261] As shown at step 2501, the flexible display 104 is presenting content 2509. The content 2509 being presented in this illustrative example is that of a trackpad. The user 2506 can interact with the trackpad to control a companion electronic device with which the electronic device 100 is in communication.

[0262] As shown, in addition to presenting an interactive area 2507 with which the user 2506 may interact to control the trackpad, the content 2509 also includes one or more user actuation

targets 2508 configured as icons. The user actuation targets 2508 include an icon to invoke a menu, and icon to undo an operation, an icon to change the trackpad to an “air” mouse, and an icon to cause the content 2509 to return to a home screen presentation. These icons are illustrative only, as numerous others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0263] At decision 2503, the one or more processors (114) detect touch input 2510 interacting with the flexible display 104. At step 2504, the one or more processors (114) in response to the detection of user input interacting with the flexible display 104, cause the translation mechanism (105) to deliver haptic feedback by translating the blade assembly 102 with an oscillatory motion back relative to a position of the blade assembly 102 relative to the device housing 101. As shown at step 2505, this haptic feedback 2511 occurs when the flexible display 104 moves by an amount necessary to provide a haptic response to the touch input 2510 received at step 2502. In one or more embodiments, this amount necessary to provide the haptic response is less than three millimeters, with the back-and-forth motion occurring for less than three seconds. As noted above, this distance and time is illustrative only, as numerous others will be obvious to those of ordinary skill in the art having the benefit of this disclosure.

[0264] Turning now to FIG. 26, illustrated therein are various embodiments of the disclosure. The embodiments of FIG. 26 are shown as labeled boxes in FIG. 26 due to the fact that the individual components of these embodiments have been illustrated in detail in FIGS. 1-25, which precede FIG. 26. Accordingly, since these items have previously been illustrated and described, their repeated illustration is no longer essential for a proper understanding of these embodiments. Thus, the embodiments are shown as labeled boxes.

[0265] Beginning at 2601, a method in an electronic device comprises detecting, by one or more processors of the electronic device, a device event. At 2601, the method comprises delivering, by a translation mechanism in response to the user input, haptic feedback by causing a blade

assembly that is coupled to a device housing, moveable between an extended position and a retracted position, and that carries a flexible display to translate relative to the device housing with an oscillatory motion.

[0266] At 2602, the device event of 2601 comprises touch input received by the flexible display. The periodic motion may, or may not, be symmetrical. At 2603, the oscillatory motion of 2602 is symmetrical.

[0267] At 2604, the oscillatory motion of 2602 causes the blade assembly to translate back and forth toward the extended position and toward the retracted position within a predefined distance. At 2605, the predefined distance of 2604 is less than three millimeters.

[0268] At 2606, the oscillatory motion of 2604 causes the blade assembly to translate back and forth toward the extended position and toward the retracted position a predefined number of times. At 2607, the predefined number of times of 2306 is less than five.

[0269] At 2608, when the blade assembly of 2602 is in the extended position when the user input is received, the oscillatory motion causes the blade assembly to translate between the extended position and another position closer to the retracted position within a predefined distance for a predefined number of times.

[0270] At 2609, the blade assembly of 2602 is further translatable to a peek position revealing a front-facing imager. At 2609, when the blade assembly of 2602 is in the peek position when the user input is received, the oscillatory motion causes the blade assembly to translate between the peek position and another position closer to the extended position within a predefined distance for a predefined number of times.

[0271] At 2610, the oscillatory motion of 2602 occurs with a predefined oscillatory pattern when the user input occurs at a location corresponding to a user actuation target presented on the flexible display. At 2611, the oscillatory motion of 2610 occurs with another predefined oscillatory pattern when the user input occurs at another location failing to correspond to the user

actuation target presented on the flexible display, wherein the predefined oscillatory pattern and another predefined oscillatory pattern are different.

[0272] At 2612, an electronic device comprises a device housing, a blade assembly carrying a blade and a flexible display and slidably coupled to the device housing, a translation mechanism operable to slide the blade assembly relative to the device housing between an extended position and a retracted position, and one or more processors operable with the translation mechanism. At 2612, the one or more processors, in response to the flexible display detecting user input interacting with the flexible display, cause the translation mechanism to deliver haptic feedback by translating the blade assembly with an oscillatory motion back and forth relative to a position of blade assembly relative to the device housing when the user input occurs.

[0273] At 2613, the position of the blade assembly of 2612 relative to the device housing when the user input occurs is the extended position. At 2613, the oscillatory motion initially moves the blade assembly toward the retracted position.

[0274] At 2614, the translation mechanism of 2613 is further operable to slide the blade assembly relative to the device housing to a peek position revealing a front-facing imager. At 2614, when the position of the blade assembly relative to the device housing when the user input occurs in the peek position, the oscillatory motion initially moves the blade assembly toward the extended position.

[0275] At 2615, the oscillatory motion of 2614 translates the blade assembly less than five millimeters. At 2616, the oscillatory motion of 2615 translates the blade assembly back and forth less than seven times.

[0276] At 2617, a method in an electronic device comprises detecting, by one or more processors, touch input interacting with a flexible display carried by a blade assembly that is slidably coupled to a device housing and movable between an extended position, a retracted position, and a peek position. At 2617, in response to the touch input the method comprises translating, by a

translation mechanism operable with the one or more processors, the blade assembly with a back-and-forth motion moving the blade assembly between the peek position and the extended position by an amount necessary to provide a haptic response to the touch input.

[0277] At 2618, the amount of 2617 necessary to provide the haptic response to the touch input is less than three millimeters. At 2619, the back-and-forth motion of 2618 lasts less than three seconds. At 2620, the back-and-forth motion of 2619 is of a first type when the touch input interacts with a user actuation target and is of a second type that is different from the first type when the touch input fails to interact with a user actuation target.

[0278] In the foregoing specification, specific embodiments of the present disclosure have been described. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the present disclosure as set forth in the claims below. Thus, while preferred embodiments of the disclosure have been illustrated and described, it is clear that the disclosure is not so limited. Numerous modifications, changes, variations, substitutions, and equivalents will occur to those skilled in the art without departing from the spirit and scope of the present disclosure as defined by the following claims.

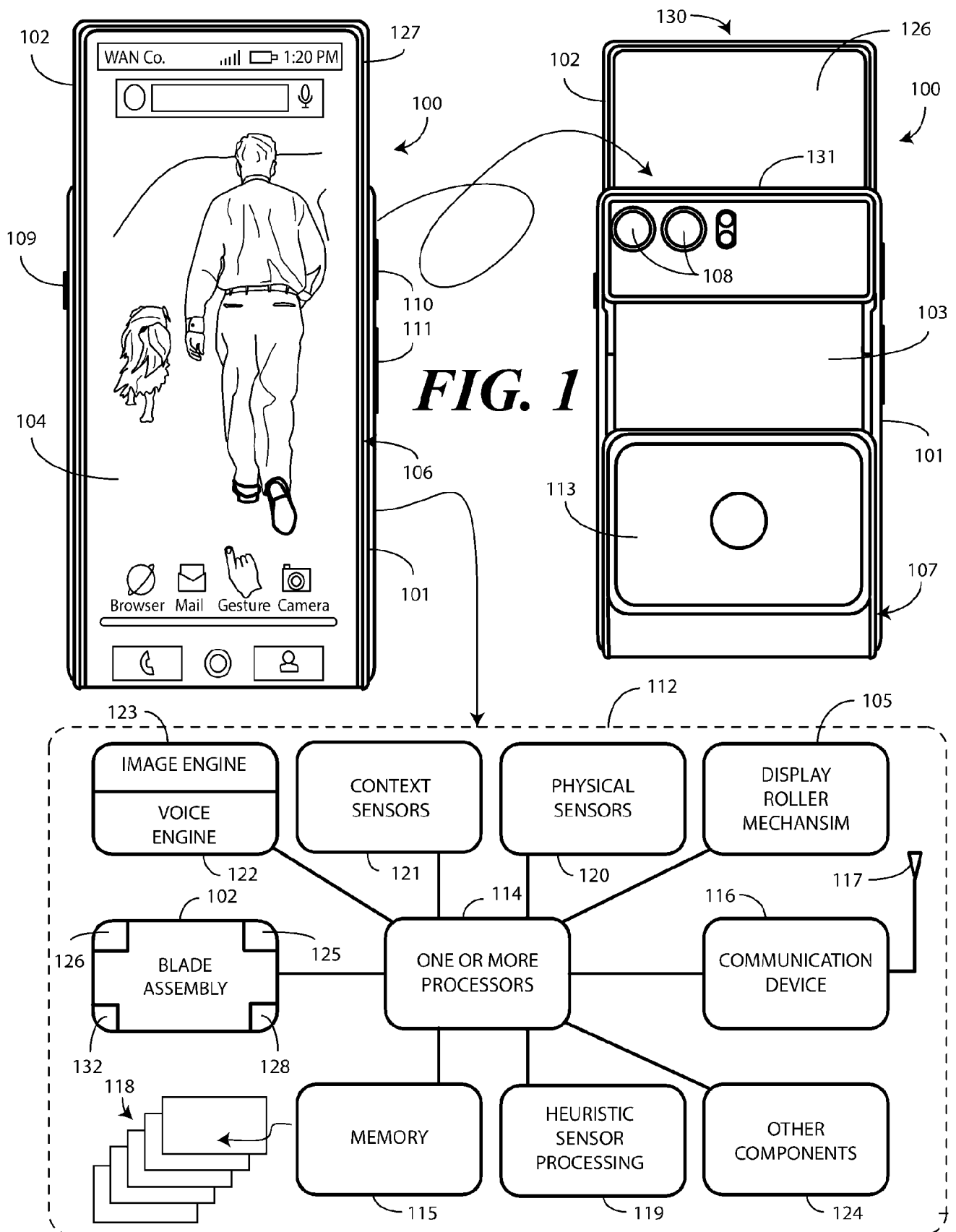
[0279] Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present disclosure. The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims.

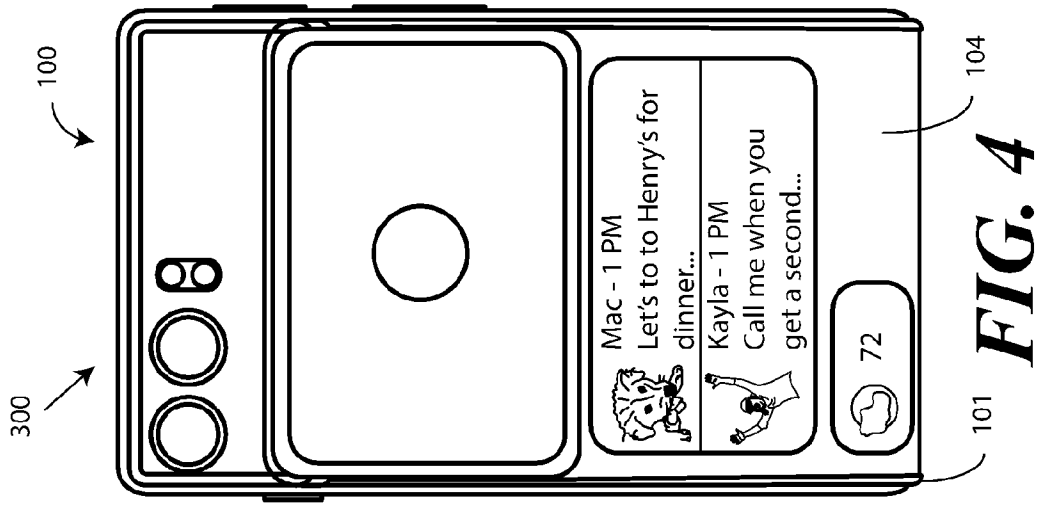
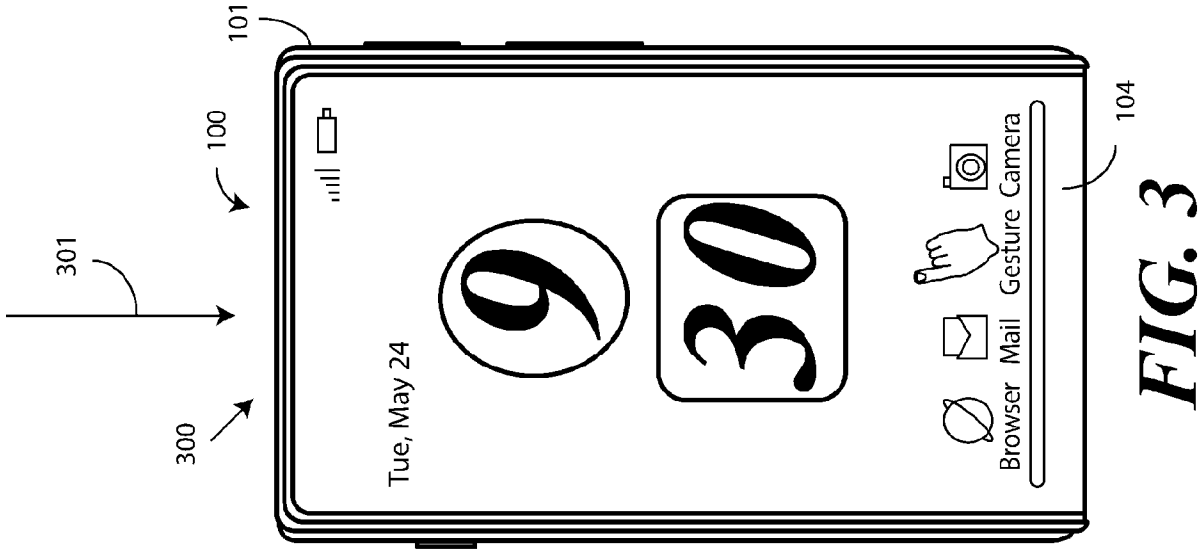
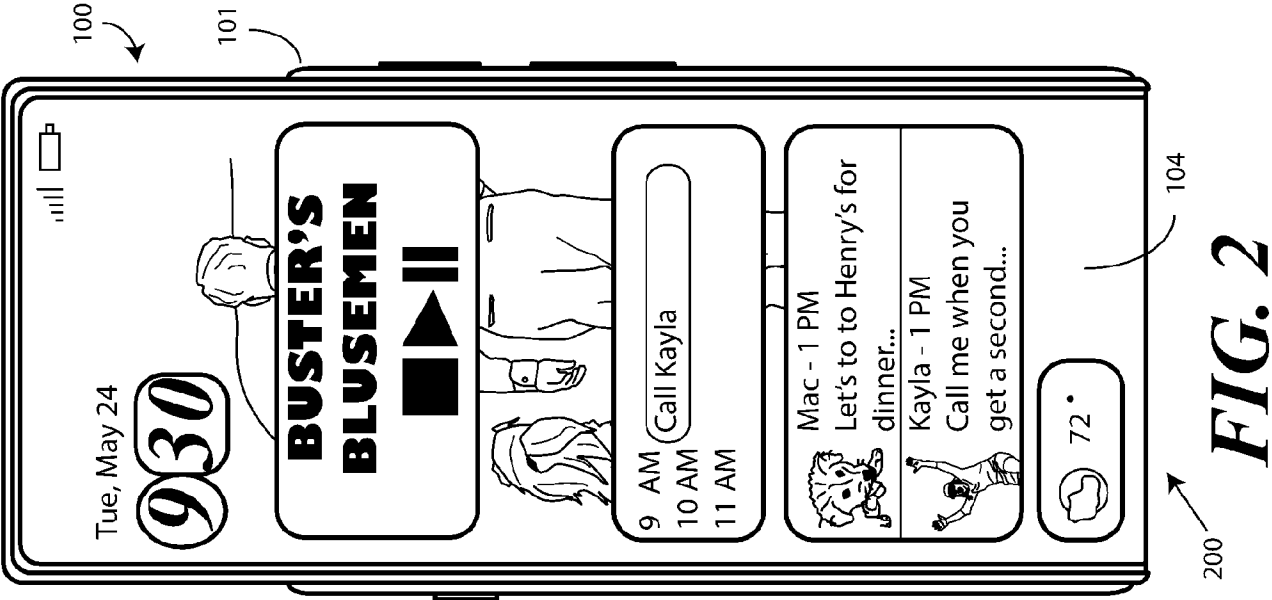
What is claimed is:

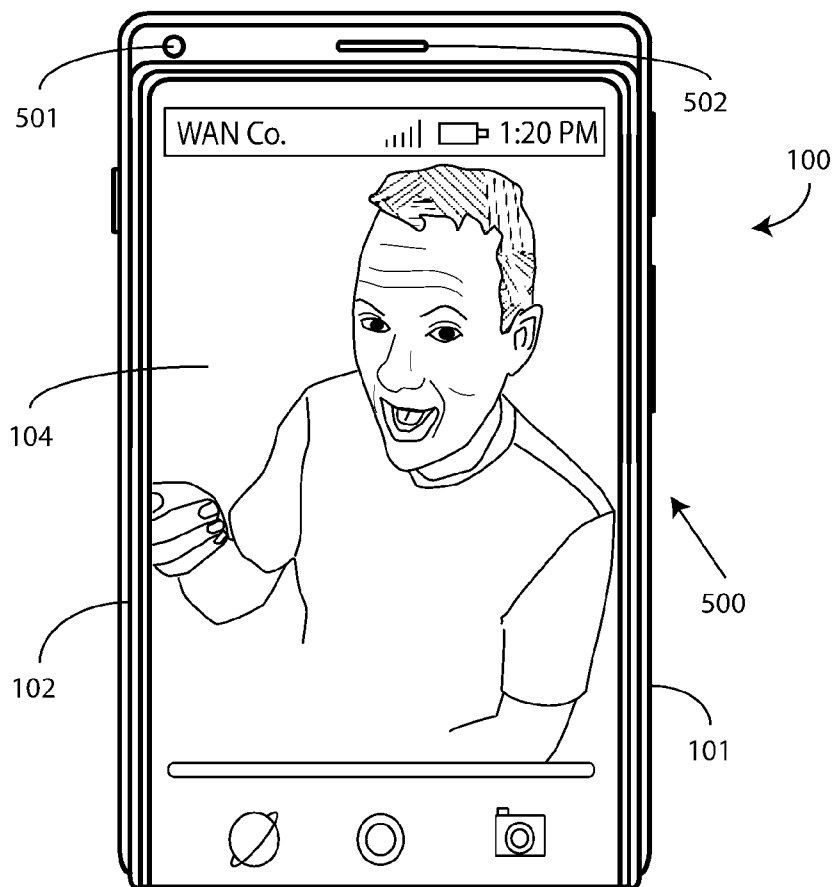
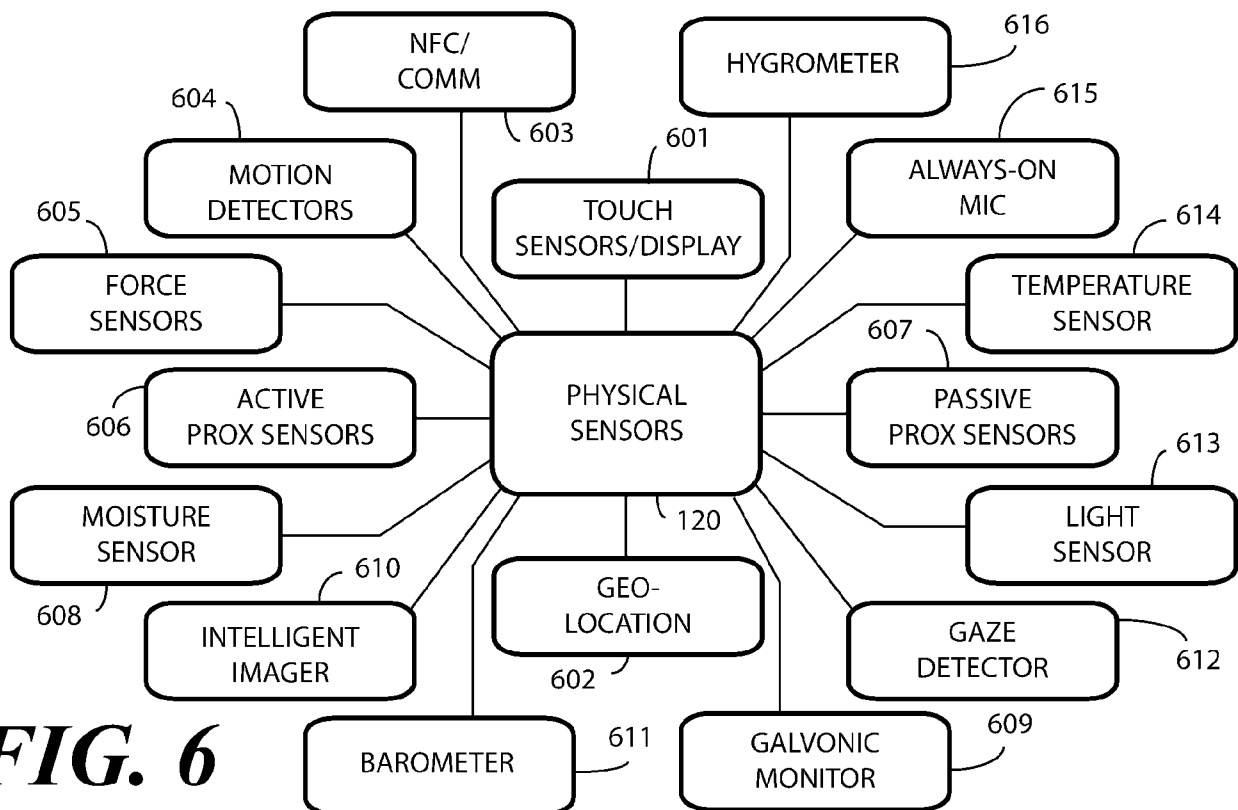
1. A method in an electronic device, the method comprising:
detecting, by one or more processors of the electronic device, a device event; and
delivering, by a translation mechanism in response to the device event, haptic
feedback by causing a blade assembly that is coupled to a device housing,
moveable between an extended position and a retracted position, and that carries
a flexible display to translate relative to the device housing with an oscillatory
motion.
2. The method of claim 1, wherein the device event comprises touch input received by the
flexible display.
3. The method of claim 2, wherein the oscillatory motion is periodic.
4. The method of claim 2, wherein the oscillatory motion causes the blade assembly to
translate back and forth toward the extended position and toward the retracted position
within a predefined distance.
5. The method of claim 4, wherein the predefined distance is less than three millimeters.
6. The method of claim 4, wherein the oscillatory motion causes the blade assembly to
translate back and forth toward the extended position and toward the retracted position a
predefined number of times.
7. The method of claim 6, wherein the predefined number of times is less than five.
8. The method of claim 2, wherein when the blade assembly is in the extended position
when the user input is received, the oscillatory motion causes the blade assembly to
translate between the extended position and another position closer to the retracted
position within a predefined distance for a predefined number of times.
9. The method of claim 2, wherein the blade assembly is further translatable to a peek
position revealing a front-facing imager, wherein when the blade assembly is in the peek

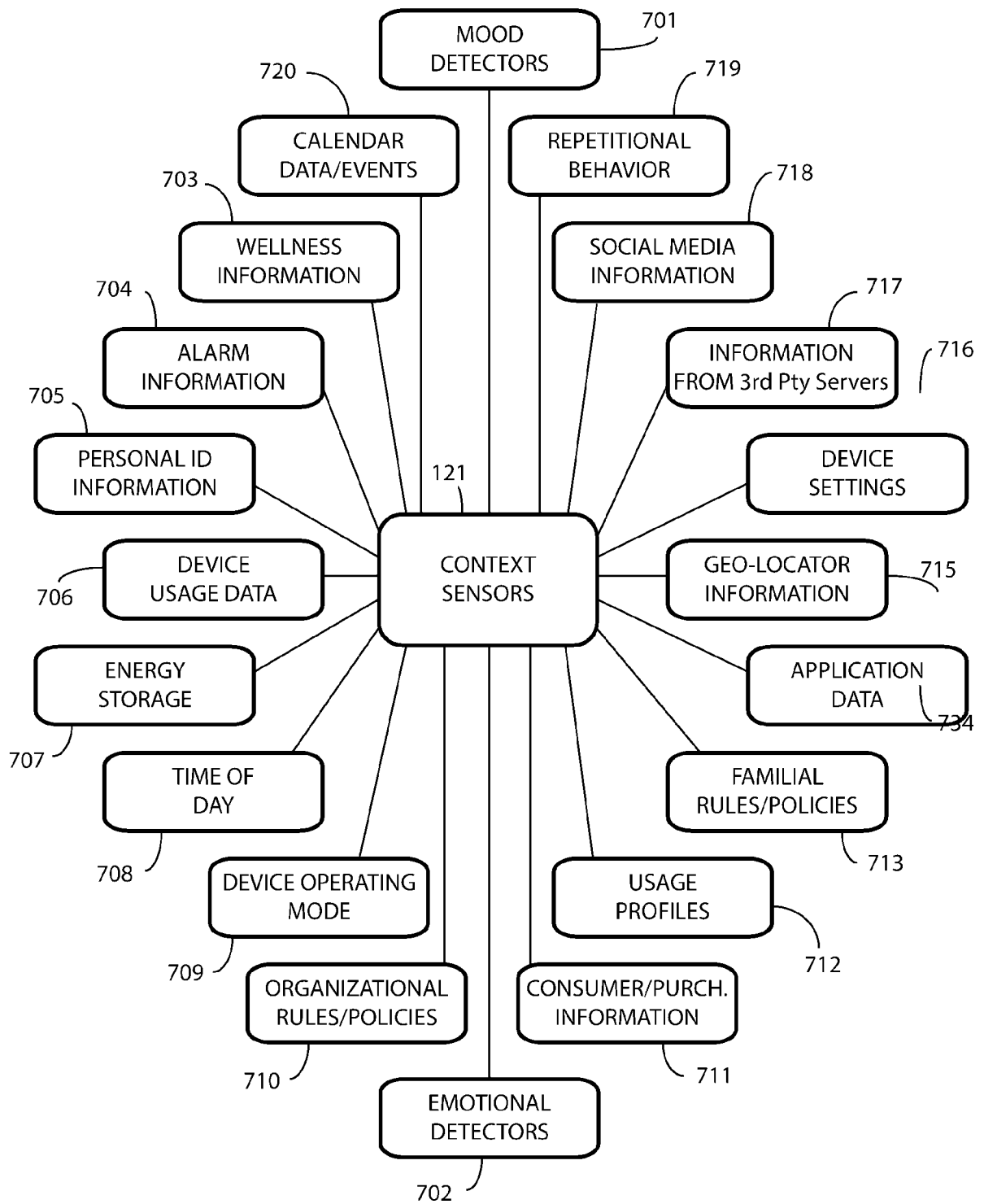
- position when the user input is received, the oscillatory motion causes the blade assembly to translate between the peek position and another position closer to the extended position within a predefined distance for a predefined number of times.
10. The method of claim 2, wherein the oscillatory motion occurs with a predefined oscillatory pattern when the user input occurs at a location corresponding to a user actuation target presented on the flexible display.
11. The method of claim 10, wherein the oscillatory motion occurs with another predefined oscillatory pattern when the user input occurs at another location failing to correspond to the user actuation target presented on the flexible display, wherein the predefined oscillatory pattern and the another predefined oscillatory pattern are different.
12. An electronic device, comprising:
- a device housing;
 - a blade assembly carrying a blade and a flexible display and slidably coupled to the device housing;
 - a translation mechanism operable to slide the blade assembly relative to the device housing between an extended position and a retracted position; and
 - one or more processors operable with the translation mechanism;
- wherein the one or more processors, in response to the flexible display detecting user input interacting with the flexible display, cause the translation mechanism to deliver haptic feedback by translating the blade assembly with an oscillatory motion back and forth relative to a position of blade assembly relative to the device housing when the user input occurs.
13. The electronic device of claim 12, wherein when the position of the blade assembly relative to the device housing when the user input occurs is the extended position, the oscillatory motion initially moves the blade assembly toward the retracted position.

14. The electronic device of claim 13, wherein the translation mechanism is further operable to slide the blade assembly relative to the device housing to a peek position revealing a front-facing imager, wherein when the position of the blade assembly relative to the device housing when the user input occurs in the peek position, the oscillatory motion initially moves the blade assembly toward the extended position.
15. The electronic device of claim 14, wherein the oscillatory motion translates the blade assembly less than five millimeters.
16. The electronic device of claim 15, wherein the oscillatory motion translates the blade assembly back and forth less than seven times.
17. A method in an electronic device, the method comprising:
 - detecting, by one or more processors, touch input interacting with a flexible display carried by a blade assembly that is slidably coupled to a device housing and movable between an extended position, a retracted position, and a peek position; and
 - in response to the touch input, translating, by a translation mechanism operable with the one or more processors, the blade assembly with a back-and-forth motion moving the blade assembly between the peek position and the extended position by an amount necessary to provide a haptic response to the touch input.
18. The method of claim 17, wherein the amount necessary to provide the haptic response to the touch input is less than three millimeters.
19. The method of claim 18, wherein the back-and-forth motion lasts less than three seconds.
20. The method of claim 19, wherein the back-and-forth motion is of a first type when the touch input interacts with a user actuation target and is of a second type that is different from the first type when the touch input fails to interact with a user actuation target.





**FIG. 5****FIG. 6**

**FIG. 7**

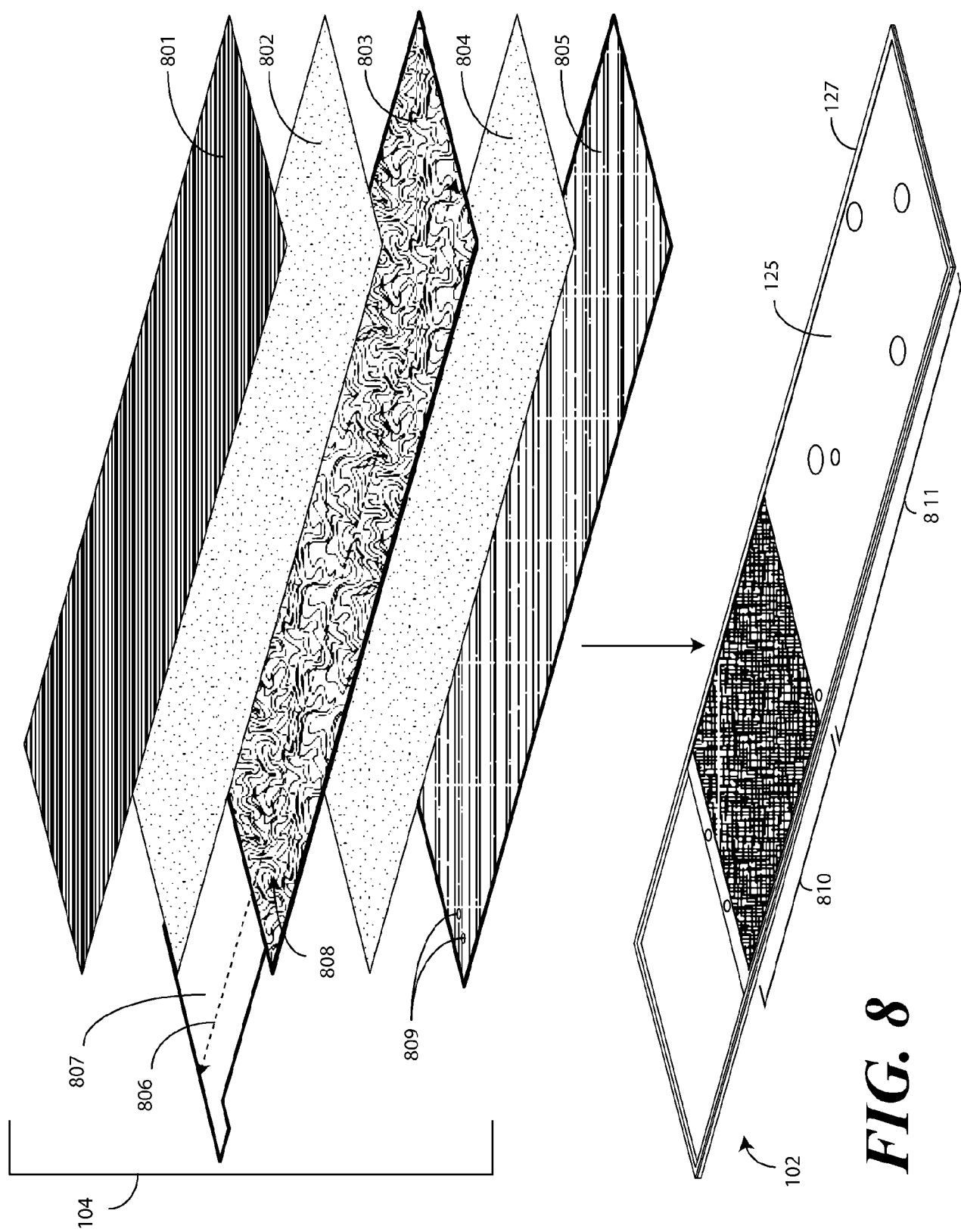
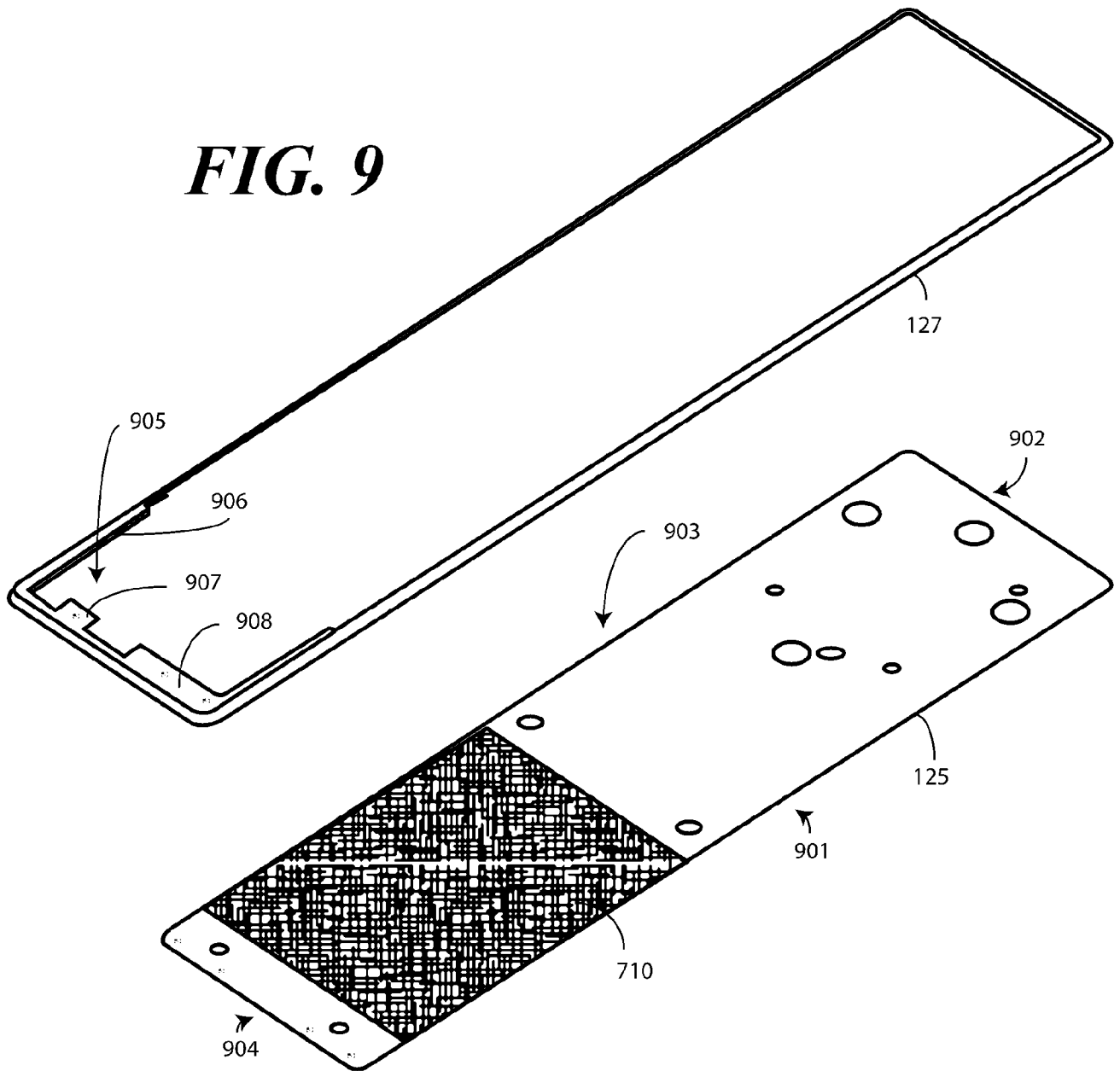
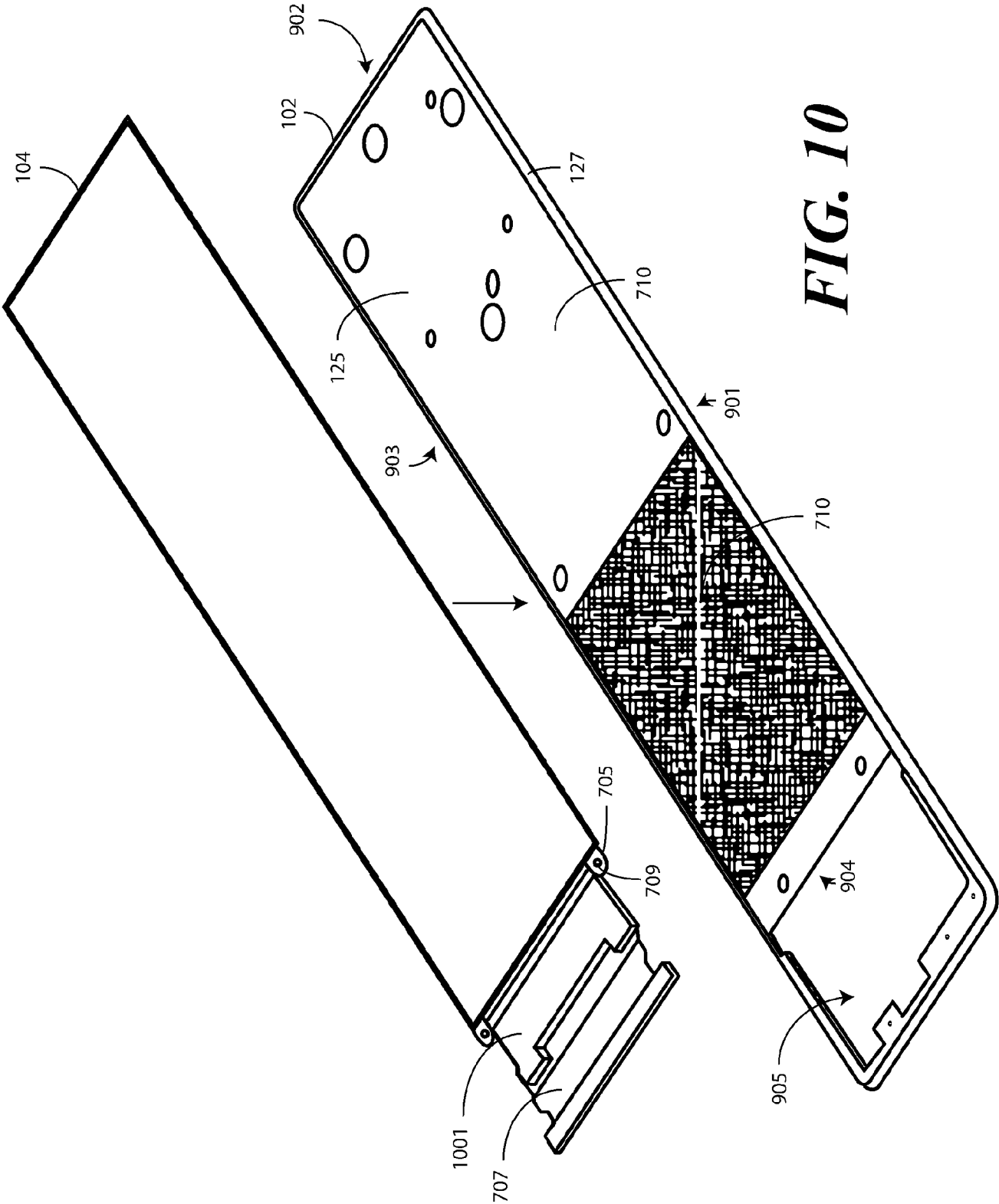
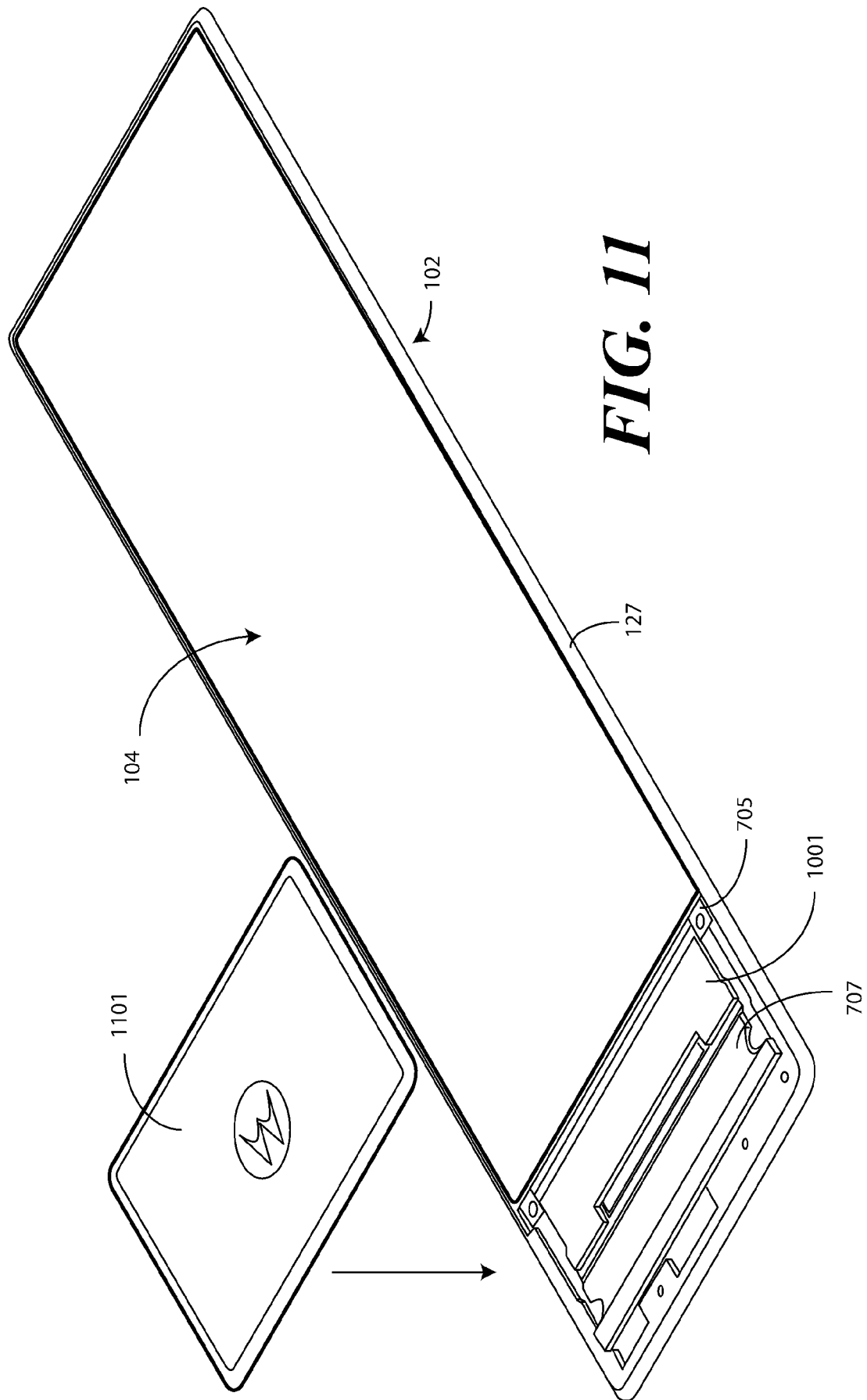


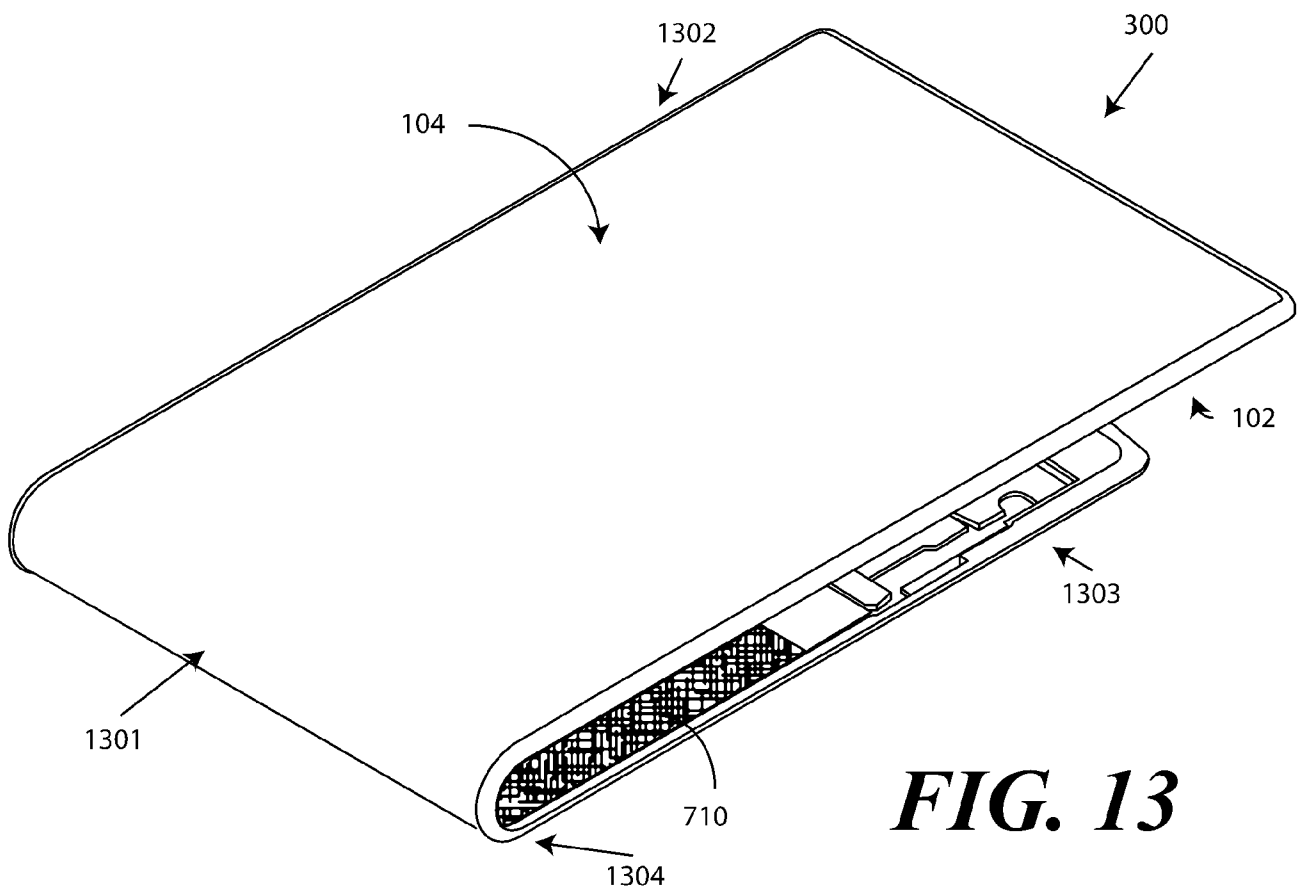
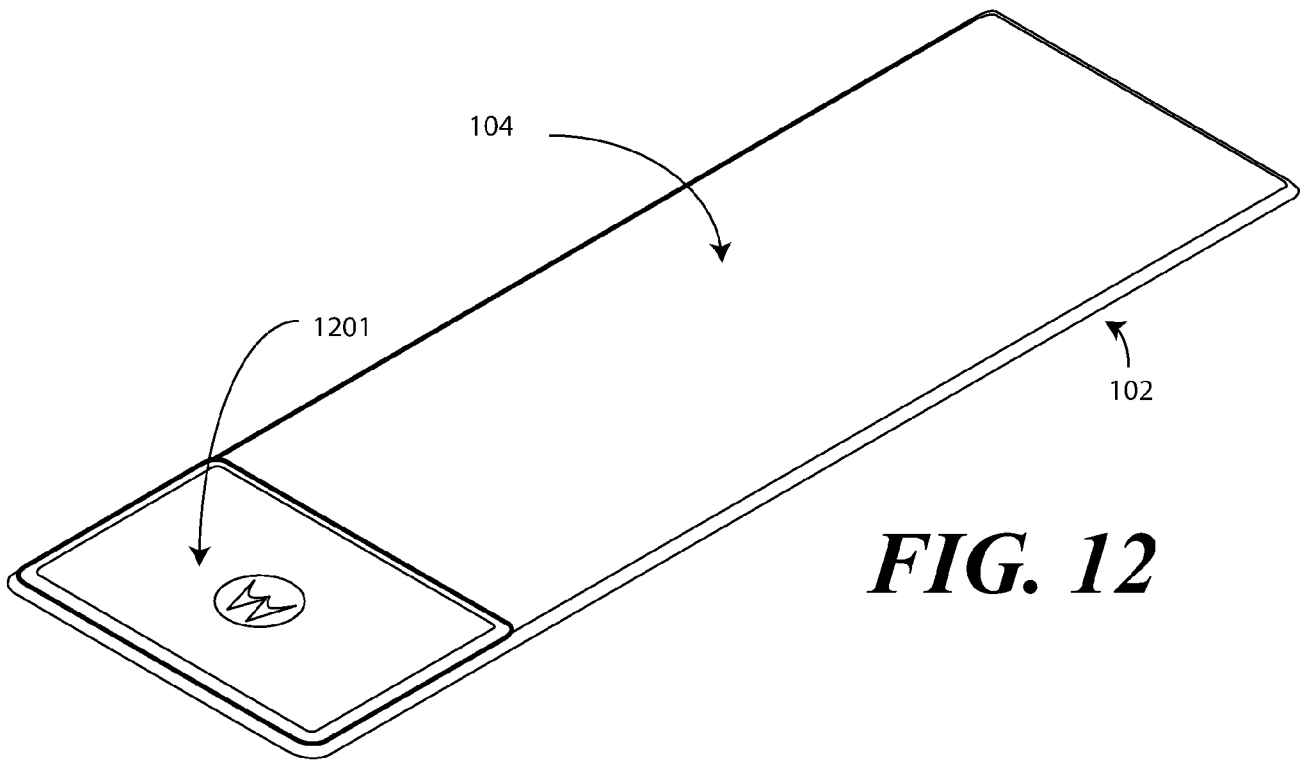
FIG. 8

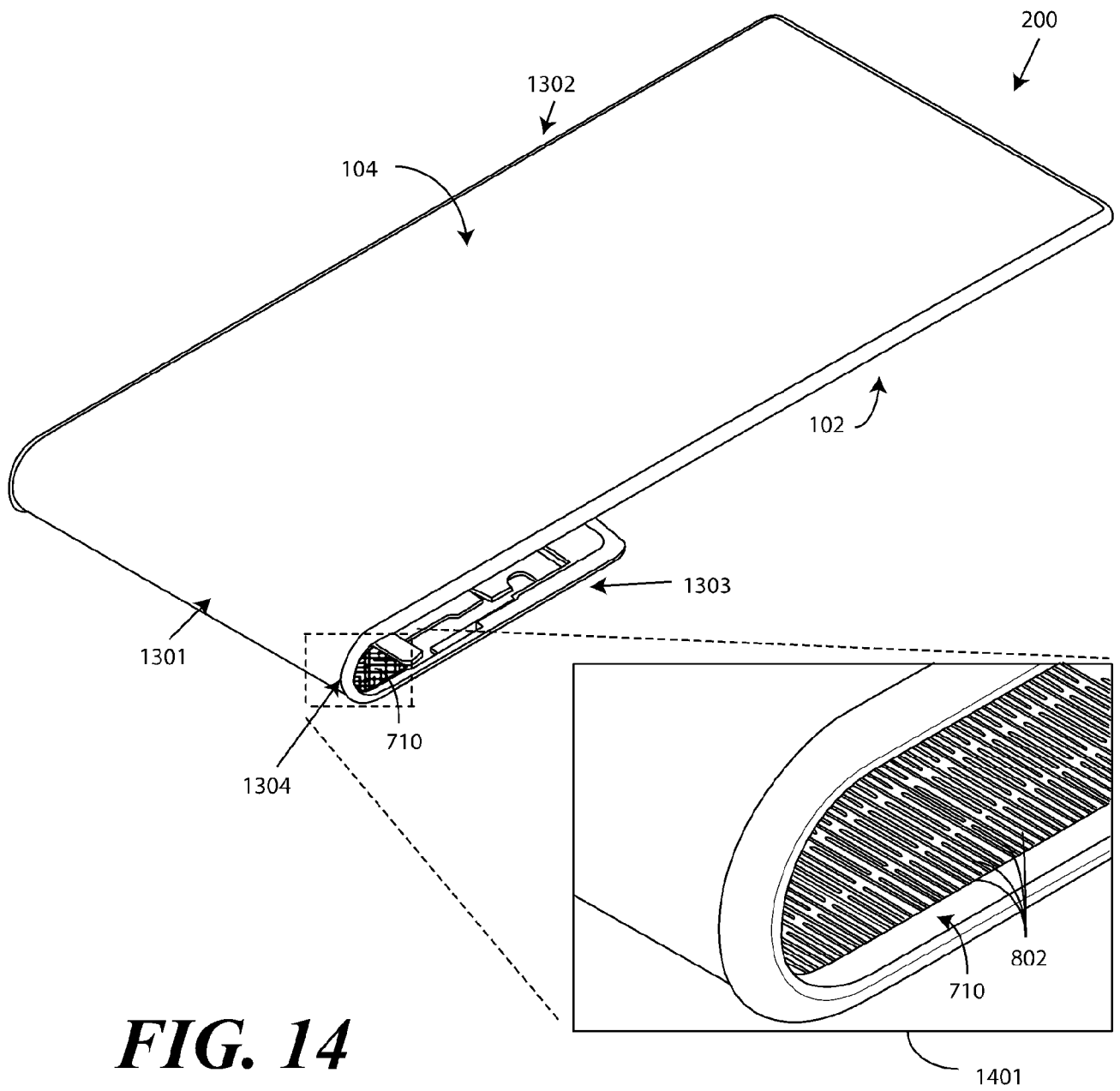
FIG. 9









**FIG. 14**

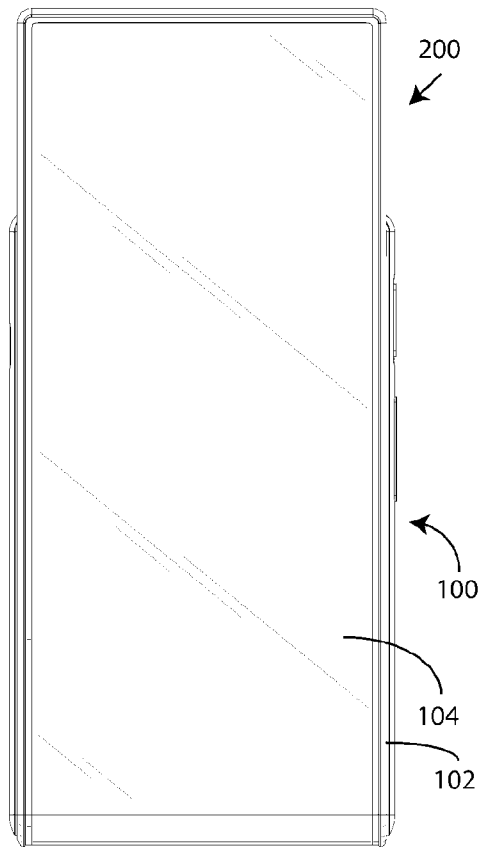


FIG. 15

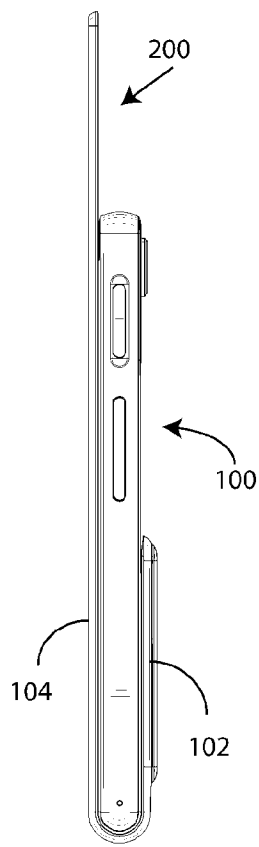


FIG. 16

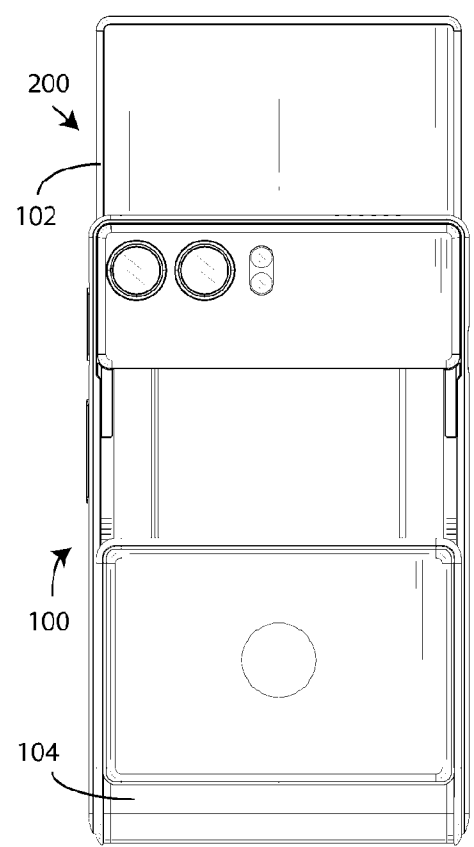


FIG. 17

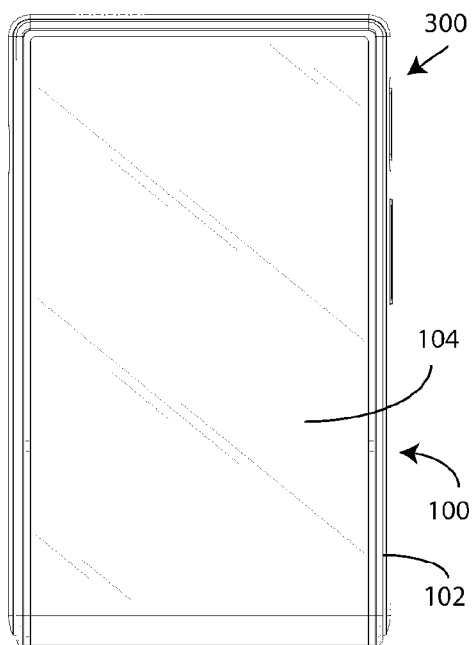


FIG. 18

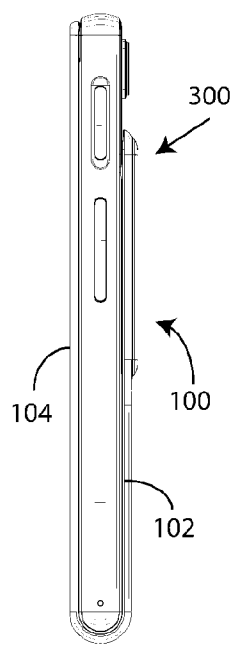


FIG. 19

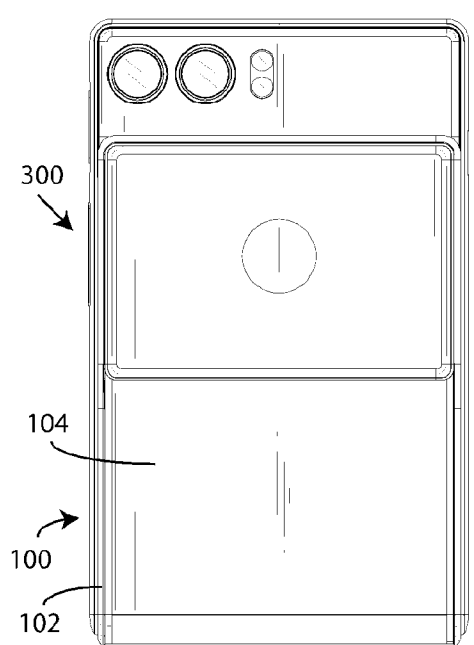


FIG. 20

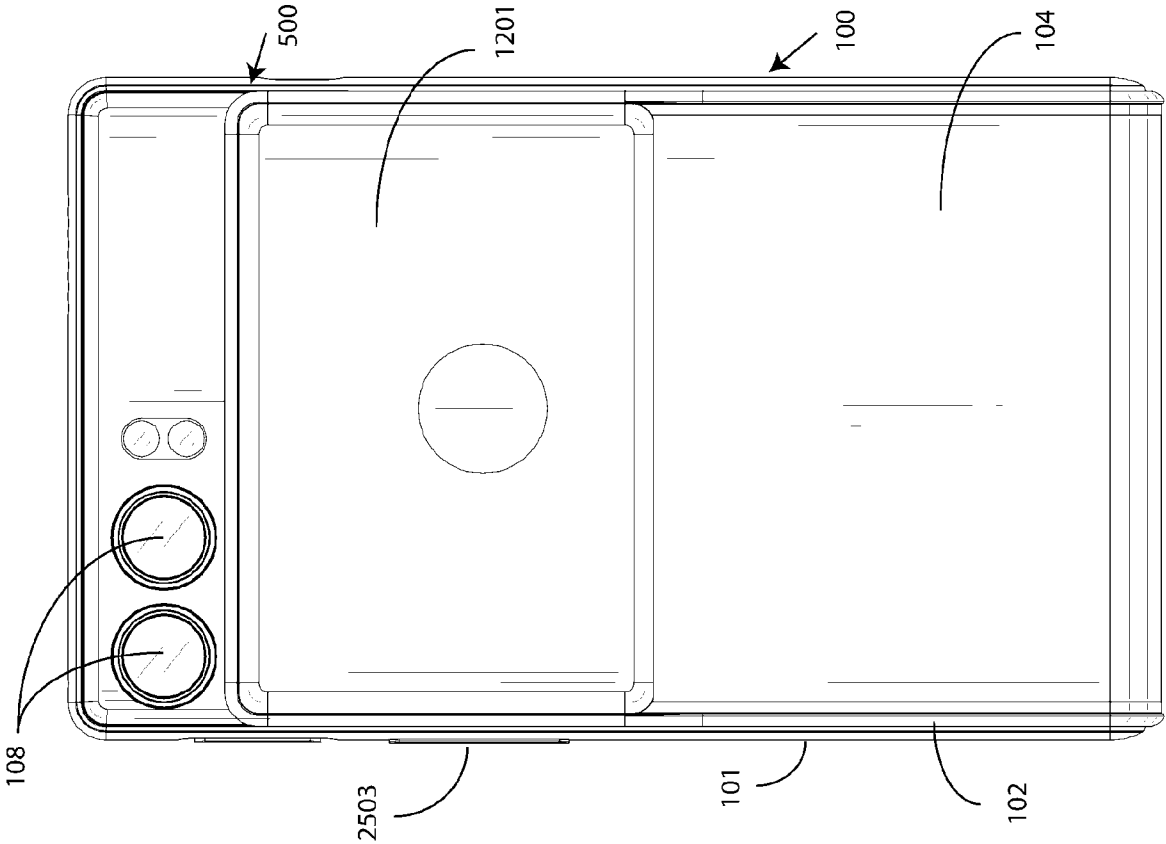


FIG. 22

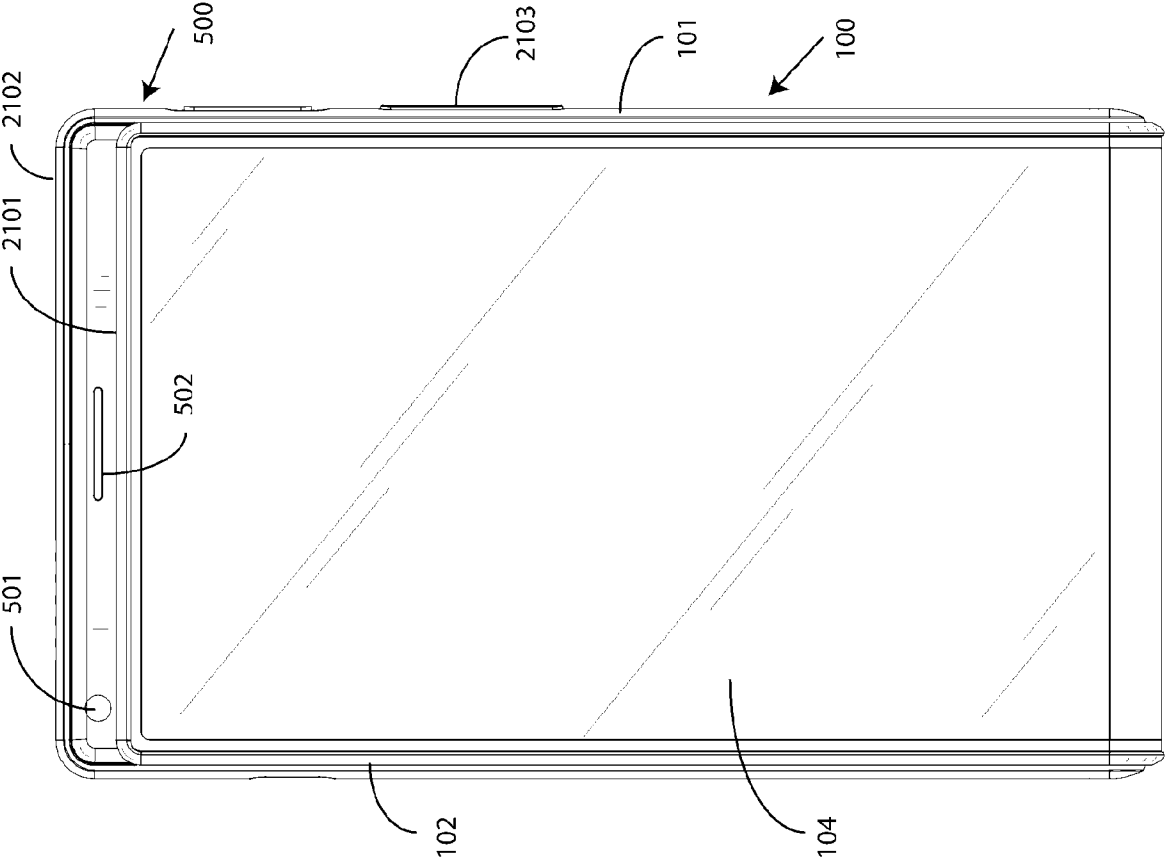
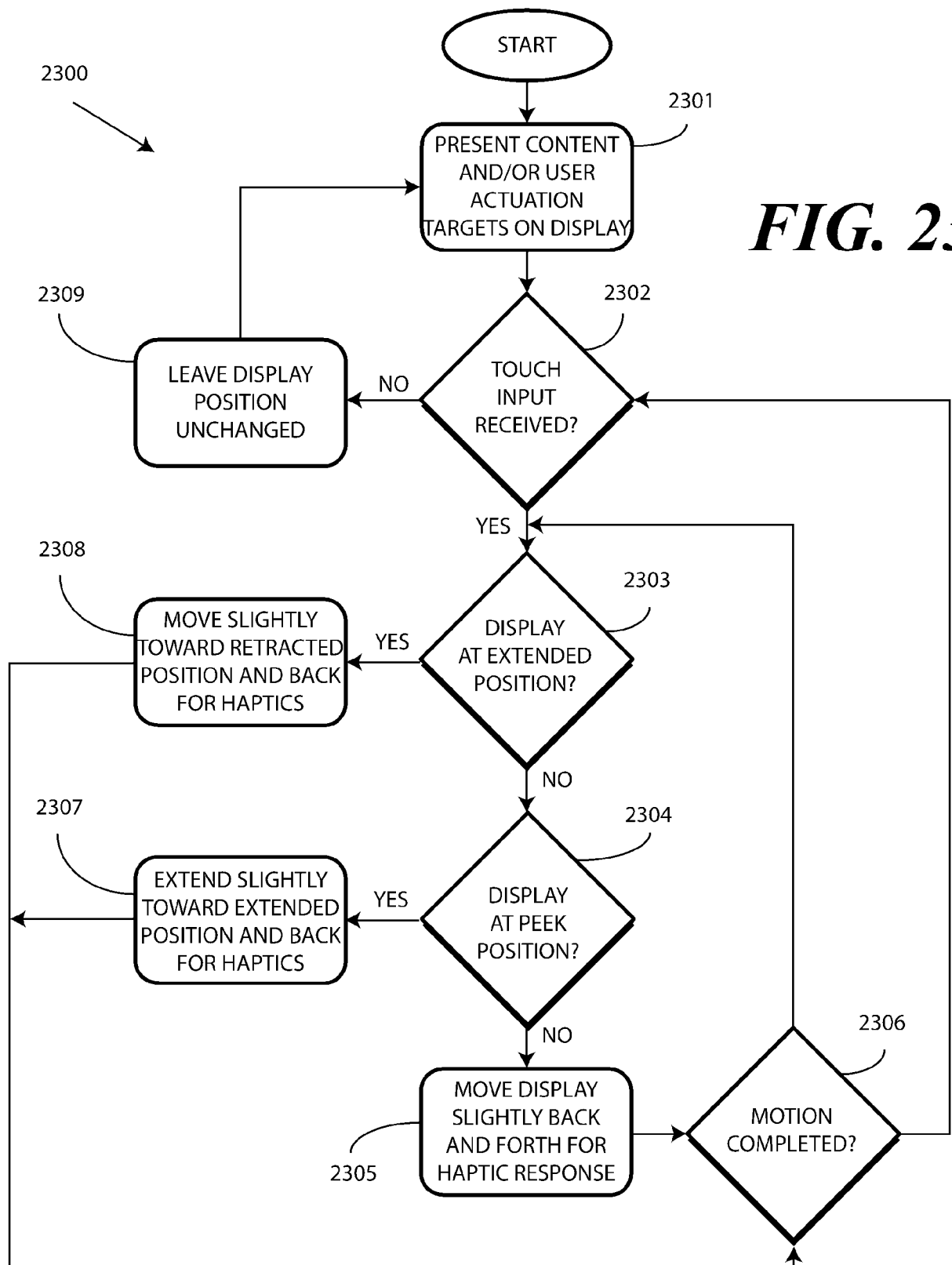
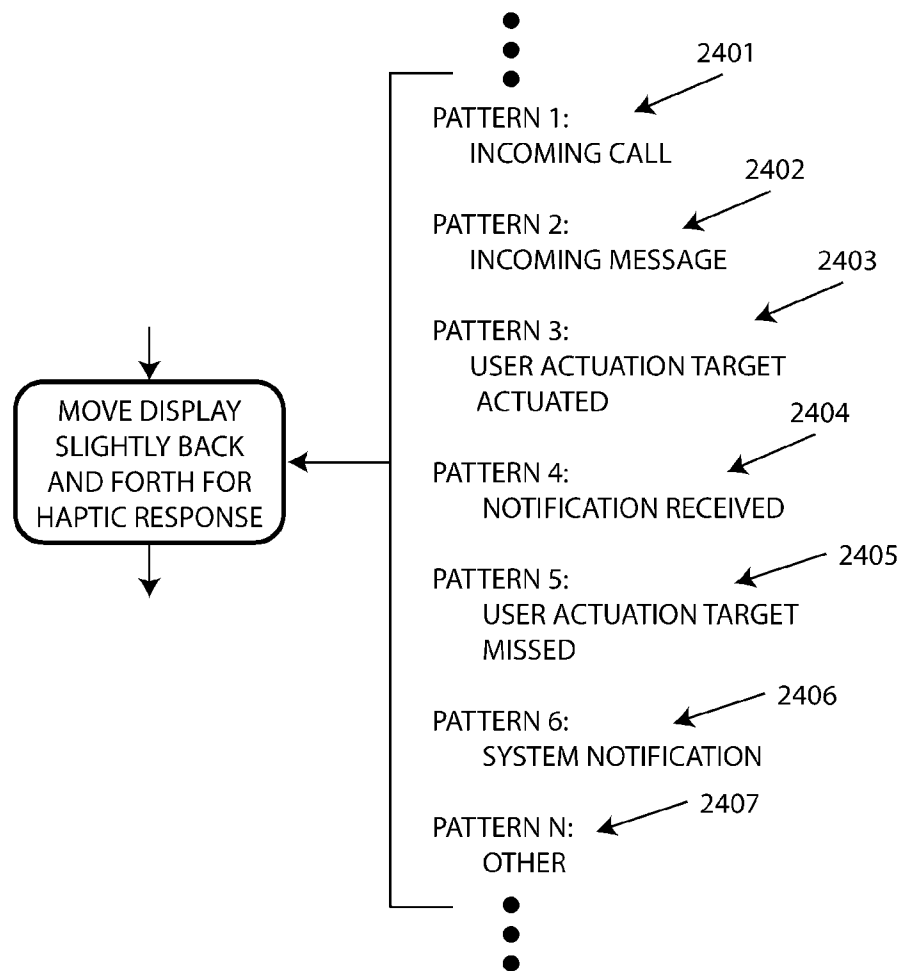
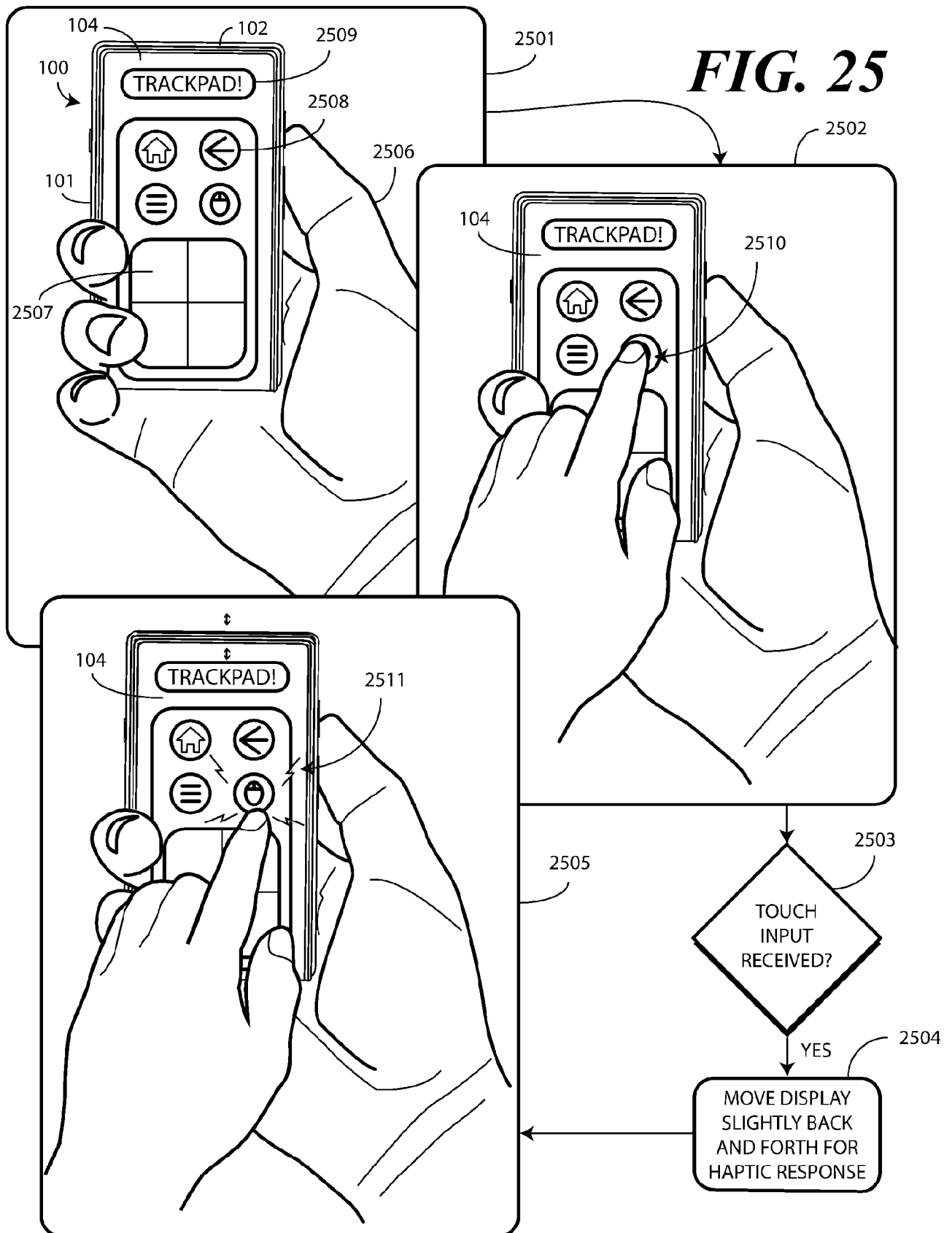


FIG. 21



**FIG. 24**



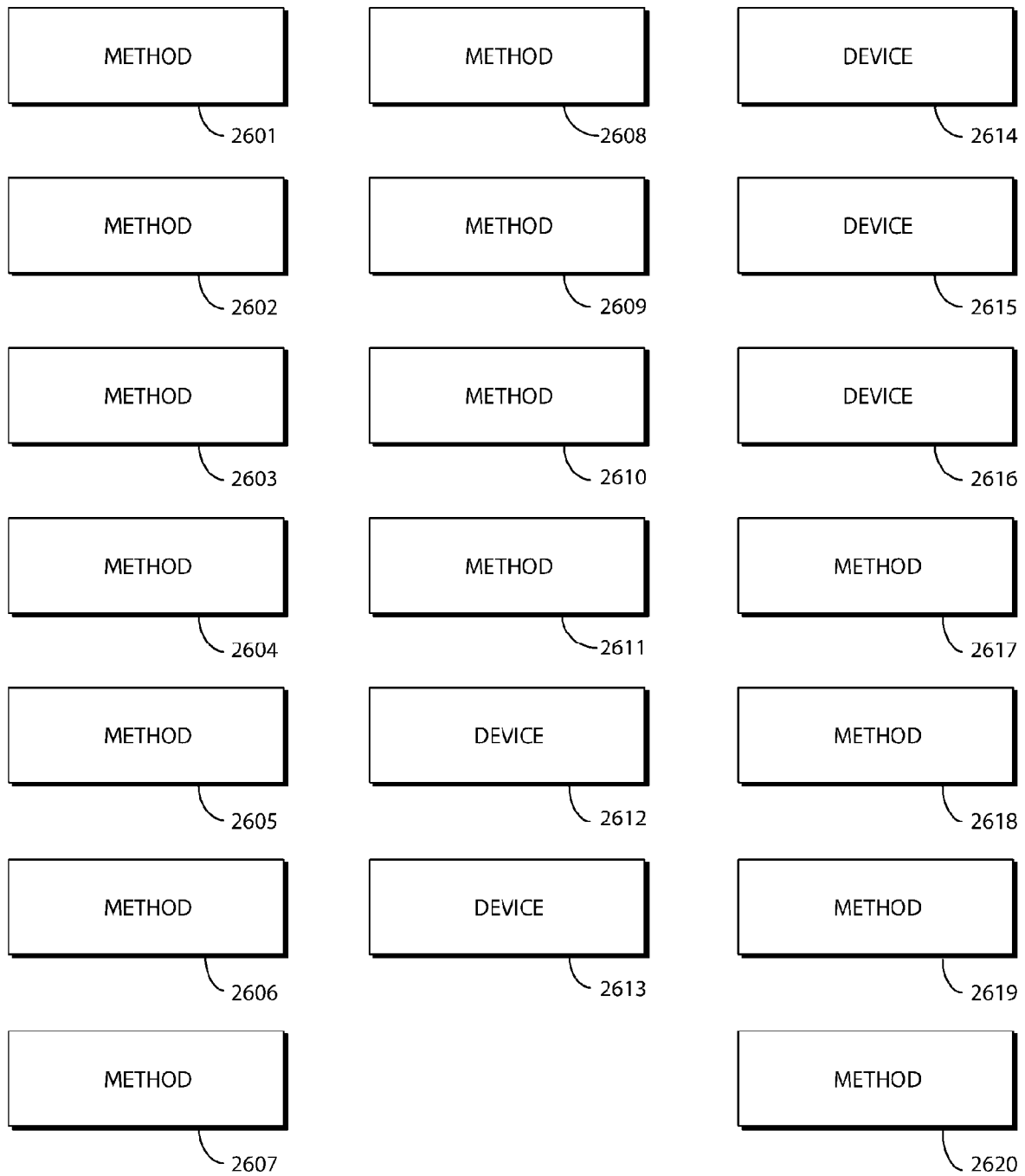


FIG. 26

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/098684

A. CLASSIFICATION OF SUBJECT MATTER

G06F 3/01(2006.01)i

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)

IPC: G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

ENTXTC, ENTXT, CNTXT, CNKI, IEEE, ISI: vibration, flexible, display, screen, movement, motion, extension, retraction, haptic, feedback, back and forth, translation, oscillation, support

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2023063858 A1 (MOTOROLA MOBILITY LLC) 02 March 2023 (2023-03-02) claims 1-20, description, paragraphs [0047]-[0059], figures 1-10	1-20
A	US 2008303782 A1 (IMMERSION CORPORATION) 11 December 2008 (2008-12-11) the whole document	1-20
A	US 2010117975 A1 (LG ELECTRONICS INC.) 13 May 2010 (2010-05-13) the whole document	1-20
A	US 2013222271 A1 (MOTOROLA MOBILITY, INC.) 29 August 2013 (2013-08-29) the whole document	1-20
A	US 2014320393 A1 (IMMERSION CORPORATION) 30 October 2014 (2014-10-30) the whole document	1-20
A	WO 2014117125 A1 (BAYER MATERIALSCIENCE LLC et al.) 31 July 2014 (2014-07-31) the whole document	1-20

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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“D” document cited by the applicant in the international application

“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

03 January 2024

Date of mailing of the international search report

09 January 2024

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/098684

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2023063858	A1	02 March 2023	GB	202212048	D0	05 October 2022
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				BR	102022016989	A2	14 March 2023
				DE	102022121120	A1	09 March 2023
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				KR	20100041733	A	22 April 2010
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				WO	2008150600	A1	11 December 2008
				JP	2010529555	A	26 August 2010
				JP	5356372	B2	04 December 2013
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				KR	20100052227	A	19 May 2010
				KR	101521219	B1	18 May 2015
				EP	2192750	A2	02 June 2010
				EP	2192750	A3	02 March 2016
				EP	2192750	B1	06 September 2017
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				EP	2820829	B1	28 November 2018
				WO	2013130203	A2	06 September 2013
				WO	2013130203	A3	05 December 2013
US	2014320393	A1	30 October 2014	JP	2018190452	A	29 November 2018
				EP	2796976	A1	29 October 2014
				EP	2796976	B1	22 January 2020
				US	2017060248	A1	02 March 2017
				US	10048758	B2	14 August 2018
				KR	20140128270	A	05 November 2014
				US	2019073035	A1	07 March 2019
				US	9524030	B2	20 December 2016
				JP	2014216025	A	17 November 2014
				JP	6382564	B2	29 August 2018
WO	2014117125	A1	31 July 2014	TW	201502859	A	16 January 2015