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(54) Title: BAND WITH HAPTIC ACTUATORS

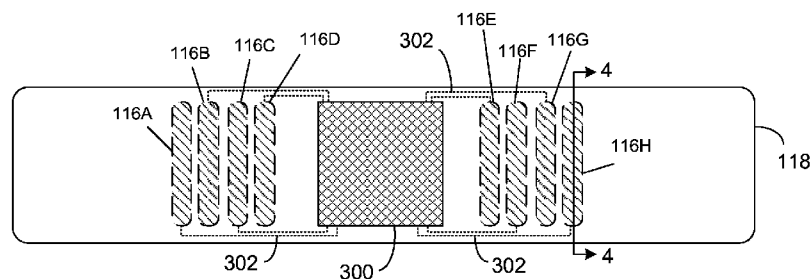


FIG. 3

(57) Abstract: A band includes one or more haptic actuators that can be activated to provide haptic stimulation to a wearer. An electronic device can be in communication with the one or more haptic actuators through a wired and/or wireless connection. The electronic device can be a separate device, or the electronic device can be removably or fixedly attached to the band. An activation signal can be sent to a single haptic actuator or to groups of two or more haptic actuators.



BAND WITH HAPTIC ACTUATORS

Technical Field

[0001] The present invention relates generally to electronic devices and more particularly to an electronic device in communication with a band having one or more haptic actuators that
5 provide haptic feedback to a wearer.

Background

[0002] Haptic feedback can be used to provide information to a user through the user's sense of touch. For example, contemporary cellular telephones and other similar electronic devices may use vibrations to denote various events, such as when a touchscreen or home
10 button is pressed. Other electronic devices, such as joysticks used in gaming systems, can vibrate or produce a force as feedback when a user interacts with onscreen actions in a video game.

[0003] But many portable electronic devices continue to decrease in size while the number of uses and functions of the electronic devices can remain the same or increase. For
15 example, some cellular phones and digital music players are contained within small and compact housings that include electronic circuits and components that provide a user with a wide range of applications and functions. Space can therefore be an issue when including or adding additional components, circuits, and functions to a portable electronic device.

Summary

[0004] In one aspect, a band can include one or more haptic actuators, where each haptic actuator is oriented along a respective axis on the band. A processing device can be
20 operatively connected to each haptic actuator. The processing device can be adapted to output an activation signal for at least one haptic actuator to produce haptic feedback defined by at least one haptic characteristic.

[0005] In another aspect, a band can include one or more haptic actuators. A method for providing haptic feedback to a wearer of the band based on at least one event can include
25 receiving a selection of an event and receiving one or more selected haptic characteristics for the event. The one or more selected haptic characteristics can be associated with the selected event, where the one or more selected haptic characteristics control a haptic
30 response of at least one haptic actuator.

Brief Description of the Drawings

[0006] Embodiments of the invention are better understood with reference to the following drawings. The elements of the drawings are not necessarily to scale relative to each other.

Identical reference numerals have been used, where possible, to designate identical features that are common to the figures.

[0007] FIG. 1 is an illustrative block diagram of an electronic device that can be in communication with one or more haptic actuators included in a band that is worn by a
5 wearer;

[0008] FIG. 2 is a top view of a band illustrating various orientations for a haptic actuator included in the band 118 shown in FIG. 1;

[0009] FIG. 3 is a top view of an electronic device attached to a band that includes one or more haptic actuators;

10 [0010] FIG. 4 is a cross-sectional view of the band and a haptic actuator taken along line 4-4 in FIG. 3;

[0011] FIG. 5 is a top view of an electronic device attached to a linked band that includes one or more haptic actuators;

[0012] FIG. 6 is a bottom view of the linked band shown in FIG. 5; and

15 [0013] FIG. 7 is a flowchart of a method for customizing haptic feedback for one or more haptic actuators in a band.

Detailed Description

[0014] Embodiments described herein can provide a band that includes one or more haptic actuators that can be activated to provide haptic stimulation to the skin of a wearer. An
20 electronic device can be in communication with the one or more haptic actuators through a wired and/or wireless connection. The electronic device can be a separate device, or the electronic device can be removably or fixedly attached to the band. When the electronic device is attached to the band, including the one or more haptic actuators in the band instead of in the electronic device reduce the size of the electronic device, or space can be
25 saved in the electronic device for other components. The electronic device can be any type of electronic device, including, but not limited to, a digital music player, a computing device, and a biometric monitor.

[0015] A processing device can be included in the electronic device that transmits activation signals to the haptic actuator or actuators. Each haptic actuator can produce a selected
30 force (e.g., pressure), motion, and/or vibratory response into a surface of the band, thereby providing tactile stimulation to the skin of the person wearing the band. An activation signal can be sent at select times to a single haptic actuator or to groups of two or more haptic actuators. Haptic stimulation can act as notifications for one or more events, such as the receipt of an email, a text message, a news story, a stock price, a reminder, and/or a low
35 power state of a power source in the electronic device.

[0016] FIG. 1 is an illustrative block diagram of an electronic device that can be in communication with one or more haptic actuators included in a band that is worn by a

wearer. The electronic device 100 can include a processing device 102, a network communication interface 104, a display 106, a memory 108, one or more sensors 110, and a power source 112. The processing device 102 can control some or all of the operations of the electronic device 100. The processing device 102 can communicate, either directly or indirectly, with substantially all of the components of the electronic device 100. For example, a system bus or signal line 114 or other communication mechanisms can provide communication between the processing device 102, the network communication interface 104, the display 106, the memory 108, the one or more sensors 110, and/or the power source 112. The processing device 102 can be implemented as any electronic device capable of processing, receiving, or transmitting data or instructions. For example, the processing device 102 can be a microprocessor, a central processing unit (CPU), an application-specific integrated circuit (ASIC), a digital signal processor (DSP), or combinations of such devices. As described herein, the term "processing device" is meant to encompass a single processor or processing unit, multiple processors, multiple processing units, or other suitably configured computing element or elements.

[0017] The network communication interface 104 can facilitate transmission of data to or from other electronic devices. For example, a network communication interface can transmit electronic signals via a wireless and/or wired network connection. Examples of wireless and wired network connections include, but are not limited to, cellular, WiFi, Bluetooth, IR, Ethernet, and radio such as near field communication.

[0018] The display 106 may provide an image or video output for the electronic device 100. The display may also provide an input surface for one or more input devices, such as, for example, a touch sensing device and/or a fingerprint sensor. The display 106 may be substantially any size and may be positioned substantially anywhere on the electronic device 100. The display 106 can be implemented with any suitable technology, including, but not limited to, a multi-touch sensing touchscreen that uses liquid crystal display (LCD) technology, light emitting diode (LED) technology, organic light-emitting display (OLED) technology, organic electroluminescence (OEL) technology, or another type of display technology.

[0019] The memory 108 can store electronic data that can be used by the electronic device 100. For example, a memory can store electrical data or content such as audio files, applications, user preferences, timing signals, video files and images, data structures or databases, documents, and device and application settings. The memory 108 can be configured as any type of memory. By way of example only, the memory can be implemented as random access memory, read-only memory, Flash memory, removable memory, or other types of storage elements, or combinations of such devices.

[0020] The electronic device 100 may also include one or more sensors 110 positioned substantially anywhere on the electronic device 100. The sensor 110 may be configured to sense substantially any type of characteristic, such as but not limited to, images, pressure, light, touch, heat, movement, relative motion, biometric data, and so on. For example, a sensor 110 may be an image sensor, a heat sensor, a light or optical sensor, an accelerometer, a pressure transducer, a gyroscope, a magnet, a biometric sensor, and so on.

[0021] The power source 112 can be implemented with any device capable of providing energy to the electronic device 100. For example, the power source 112 can be one or more batteries or rechargeable batteries, or a connection cable that connects the remote control device to another power source such as a wall outlet.

[0022] The processing device 102 is in communication and operatively connected to one or more haptic actuators 116 that are included in a band or strap 118 worn by a user. Each haptic actuator can produce a selected force (e.g., pressure), motion, and/or vibratory response into the surface of the band, thereby providing tactile stimulation to the skin of the person wearing the band. The one or more haptic actuators can be implemented with any suitable haptic technology, including, but not limited to, electromagnetic technology, piezoelectric technology, and/or electro-reactive polymers. The processing device 102 can transmit activation signals to one or more selected haptic actuators through a wired and/or wireless network connection 120 created between network communication interface 104 in the electronic device 100 and network communication interface 122 in the band 118. Based on the received signal(s), each haptic actuator 116 produces a tactile vibration in the band (or the surface of the band) under and around the haptic actuator.

[0023] The processing device 102 can include a waveform generator 124 configured to dynamically produce waveforms appropriate to activate selected haptic actuators 116 to produce tactile vibrations. In some embodiments, the processing device 102 can access the memory 108 to retrieve waveform data that is received by the waveform generator 124. The waveform generator 124 can produce an appropriate waveform for one or more of the haptic actuators 116. As will be described in more detail later, an appropriate waveform can be determined by one or more haptic characteristics, such as frequency, timing, direction, and/or duration.

[0024] It should be noted that **FIG. 1** is illustrative only. In other examples, an electronic device may include fewer or more components than those shown in **FIG. 1**. For example, when the electronic device can be attached to the band, the network connection 120 and the network communication interface 122 in the band 118 can be omitted and the activation signals transmitted to the haptic actuators via signal lines included in the band. **FIG. 3** depicts signal lines embedded in a band.

[0025] As another example, an electronic device can include one or more input/output (I/O) devices that can receive data from a user or one or more other electronic devices. One example of an I/O device is button, such as a home button, a button to increase or decrease volume, and/or an on/off button. An I/O device can include a touch sensing input surface such as a trackpad, one or more buttons, one or more microphones or speakers, one or more ports such as a microphone port, and/or a keyboard.

[0026] In some embodiments, the components shown in the electronic device 100 can be omitted from the device but included in the band 118. Additionally or alternatively, one or more components in the electronic device 100 can be duplicated in the band 118. For example, a processing device can be included in the band and connected between the network communication interface 122 and the haptic actuators 116.

[0027] Referring now to **FIG. 2**, there is shown a top view of a band illustrating various orientations for a haptic actuator included in the band 118 shown in **FIG. 1**. In the illustrated embodiment, three haptic actuators 116A, 116B, and 116C are each oriented along a different axis A1, A2, and A3, respectively. The haptic actuators 116A, 116B, 116C can be embedded within the band 118 and are therefore depicted with dashed lines in **FIG. 2**. As one example, each haptic actuator can be sewn into the band or attached with an adhesive. The band 118 can be made of any suitable material, such as leather, metal, silicone or rubber, nylon, and ceramic.

[0028] Each actuator 116A, 116B, 116C can be configured to produce one or more selected force, motion, and/or vibratory responses. By way of example only, the haptic actuator 116A can move or vibrate laterally along the axis A1 (i.e., up and down in the figure). Similarly, haptic actuator 116B can produce a force on a surface of the band 118, which can be detected at a contact location on the skin of the wearer. The haptic actuators 116A, 116B, 116C can be distributed around the band in any given arrangement.

[0029] **FIG. 3** is a top view of an electronic device attached to a band that includes one or more haptic actuators. In some embodiments, the electronic device 300 can be removably attached to the band 300, such as with fastening or locking features, or through other attachment mechanisms such as a pocket. This can allow a user to attach different types of electronic devices to the band that interact with the haptic actuators 304. In other embodiments, the electronic device 300 can be fixedly attached to the band 302. Example electronic devices include a digital music player, a biometric monitor, a computing device, and a watch.

[0030] Selected haptic actuators 116 can receive an activation signal from the electronic device 300 via signal lines or traces 302. The signal lines 302 can be embedded in the band 118 as well as the haptic actuators 116, and are therefore shown with dashed lines in **FIG. 3**. Other embodiments can use different transmission mechanisms to transmit the activation

signals to the haptic actuators. For example, a flexible circuit or soft contact pads formed with a conductive polymer can be used to transmit activation signals to the haptic actuators.

[0031] An activation signal can be sent to a single haptic actuator or to groups of two or more haptic actuators. In example embodiments, the haptic actuator 116A can be activated by itself, or the haptic actuators 116C, 116D, 116E, 116F can be simultaneously activated. In another embodiment, the haptic actuators 116A through 116H can be activated sequentially one at a time or in groups in a variety of sequences. For example, one sequence can include activating each haptic actuator one at a time in the order 116A, 116B, 116C, 116D, 116E, 116F, 116G, 116H. As another example, one sequence can include activating each haptic actuator in groups of two in the order 116A and 116H, 116B and 116G, 116C and 116F, and then 116D and 116E.

[0032] FIG. 4 is a cross-sectional view of the band and a haptic actuator taken along line 4-4 in FIG. 3. In the illustrated embodiment, the haptic actuator 116H is an electromagnetic actuator that can produce motion in the directions indicated by arrows 400. In other embodiments, the haptic actuator 116H can produce motion in only one direction.

[0033] The electromagnetic actuator 116H includes coils or windings of wire 402 wrapped around a core 404. This type of actuator is known as a solenoid. The core 404 can include first magnets 406 with ferromagnetic spacers 408 positioned between each pair of first magnets 406. The first magnets 404 produce a magnetic field when an electrical current is passed through the solenoid, which can cause the actuator to move. The direction and velocity of the movement can be controlled by the amount and direction of the current through the coils 402. Bumpers 410 can be positioned at the ends of the core to protect the adjacent first magnets 406 from damage and from striking the edges of the core 404.

[0034] Other embodiments can construct a haptic actuator differently. As described earlier, the haptic actuators can be implemented with any suitable haptic technology, including, but not limited to, electromagnetic technology, piezoelectric technology, and/or electro-reactive polymers.

[0035] Referring now to FIG. 5, there is shown a top view of an electronic device attached to a linked band that includes one or more haptic actuators. FIG. 6 is a bottom view of the linked band shown in FIG. 5. With reference to FIGS. 5 and 6, the linked band 500 includes multiple links 502 held together with one or more pins 504. The linked band 500 can be constructed as a pin and center link locking tube bracelet or a split pin bracelet in some embodiments.

[0036] An electronic device 506 can be attached to the linked band 500 using any suitable attachment mechanisms, such as with a spring bar (not shown) positioned on each side of the electronic device to hold the band to the electronic device. In some embodiments, a haptic actuator 508 can be included in one or more links 502 of the band 500, one or more

pins 504 used to hold the links 502 together, or in one or more pins and links in the band 500. Although **FIG. 5** shows only one signal line 510 running through the links 502, additional signal lines or traces (e.g., signal lines 302 in **FIG. 3**) can be routed to respective haptic actuators 508 through one or more links and/or through one or more pins in some embodiments.

[0037] Embodiments can position the one or more haptic actuators 508 in any suitable location and/or orientation in the linked band. Each haptic actuator can be configured to produce a force in one or more contact locations, or to produce a motion, and/or vibration in one or more directions.

[0038] **FIG. 7** is a flowchart of a method for customizing haptic feedback for one or more haptic actuators in a band. Initially, a list of events can be presented to a user at block 700. The list of events can include events that can be generated or received by an electronic device. The list of events can be associated with an application and/or function running on, or connected to the electronic device. A wearer of the band can be notified of one or more events with haptic feedback. For example, haptic feedback can be produced when an email or text message is received, when a voicemail or call is received (when the electronic device is a mobile telephone), when the power source (e.g., 112 in **FIG. 1**) is in a low power state, when a navigation program provides turn-by-turn directions, and/or when an emergency alert is received. Haptic feedback can be used to notify a wearer of an upcoming meeting or activity scheduled in a calendar program. The notifications can be event based and/or location based. For example, a user can receive news alerts or notifications for particular events, such as sporting events. Similarly, the notifications can relate to one or more particular geographical locations, such as a city or neighborhood. Notifications can be associated with the weather, when a motion sensor is activated in the home, and/or when a car alarm is activated. These example events are illustrative only, and haptic feedback can be used to notify a wearer of other types of events.

[0039] Next, as shown in block 702, a determination is made as to whether an event has been selected by the user. If not, the method ends. When an event is selected, the process passes to block 704 where one or more haptic characteristics can be presented to the user.

Example haptic characteristics include, but are not limited to, whether to receive haptic feedback or not, a number of haptic actuators to be activated for haptic stimulation, the specific actuator or actuators to be activated, the timing of the activation of one or more haptic actuators, a frequency or intensity of the haptic feedback, a direction or type of movement, and/or the duration of the haptic feedback. The one or more haptic characteristics can be presented as a list in a menu or through a set of radio buttons or dialog boxes. In some embodiments, the presentation of haptic characteristics can be organized by the type of haptic stimulation, such as by a force or by a movement. A user

can customize the haptic feedback by specifying particular information for the one or more haptic characteristics. As one example, a user can specify movement in one direction at a given intensity for a particular time period.

5 **[0040]** In some embodiments, the haptic characteristic(s) associated with an event can be set at a default setting. For example, the default setting can be set to disable the haptic stimulation, or set to a given setting that produces a minimum level of haptic feedback. The method shown in **FIG. 7** can allow the user to modify the default settings.

10 **[0041]** A determination is then made at block 706 as to whether a user has modified one or more haptic characteristics for the selected event. If not, the method ends. When a user has modified one or more haptic characteristics, the method continues at block 708 where the customized haptic characteristic(s) are received and stored in a memory (e.g., memory 108 in **FIG. 1**). The customized haptic characteristic(s) can then be used each time a notification is to be sent to a user.

15 **[0042]** Various embodiments have been described in detail with particular reference to certain features thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the disclosure. And even though specific embodiments have been described herein, it should be noted that the application is not limited to these embodiments. In particular, any features described with respect to one embodiment may also be used in other embodiments, where compatible. Likewise, the
20 features of the different embodiments may be exchanged, where compatible.

CLAIMS

We claim:

1. A system, comprising:
a band comprising one or more haptic actuators, wherein each haptic actuator is oriented along a respective axis on the band; and
a processing device operatively connected to each haptic actuator, wherein the
5 processing device is adapted to output an activation signal for at least one haptic actuator to produce haptic feedback defined by at least one haptic characteristic.
2. The system as in claim 1, wherein the processing device is included in a first electronic device attached to the band.
3. The system as in claim 2, wherein the electronic device includes a display.
4. The system as in claim 2, wherein the electronic device comprises a watch.
5. The system as in claim 2, wherein the electronic device comprises a digital music player.
6. The system as in claim 2, further comprising one or more sensors operatively connected to the processing device.
7. The system as in claim 2, wherein the electronic device comprises a biometric monitor.
8. The system as in claim 1, wherein the electronic device includes a network connection interface.
9. The system as in claim 8, wherein the processing device is included in second electronic device and the processing device is operatively connected to each haptic actuator through the network connection interface and a network connection.
10. The system as in claim 9, wherein the second electronic device comprises a computing device.
11. The system as in claim 1, wherein at least one haptic actuator comprises an electromagnetic actuator.
12. The system as in claim 1, wherein the band comprises a plurality of links connected together by pins, wherein at least one connecting pin comprises a haptic actuator.

13. The system as in claim 1, wherein the band comprises a plurality of links connected together by connecting pins, wherein at least one link comprises a haptic actuator.

14. A method for providing haptic feedback to a wearer of a band, wherein the band comprises at least one haptic actuator in the band, the method comprising:

receiving a selection of an event;

receiving one or more selected haptic characteristics for the event; and

5 associating the one or more selected haptic characteristics with the selected event, wherein the one or more selected haptic characteristics control a haptic response of at least one haptic actuator.

15. The method as in claim 14, further comprising displaying a list of events prior to receiving the selection of the event.

16. The method as in claim 14, further comprising storing the associated one or more haptic characteristics and the selected event in a memory.

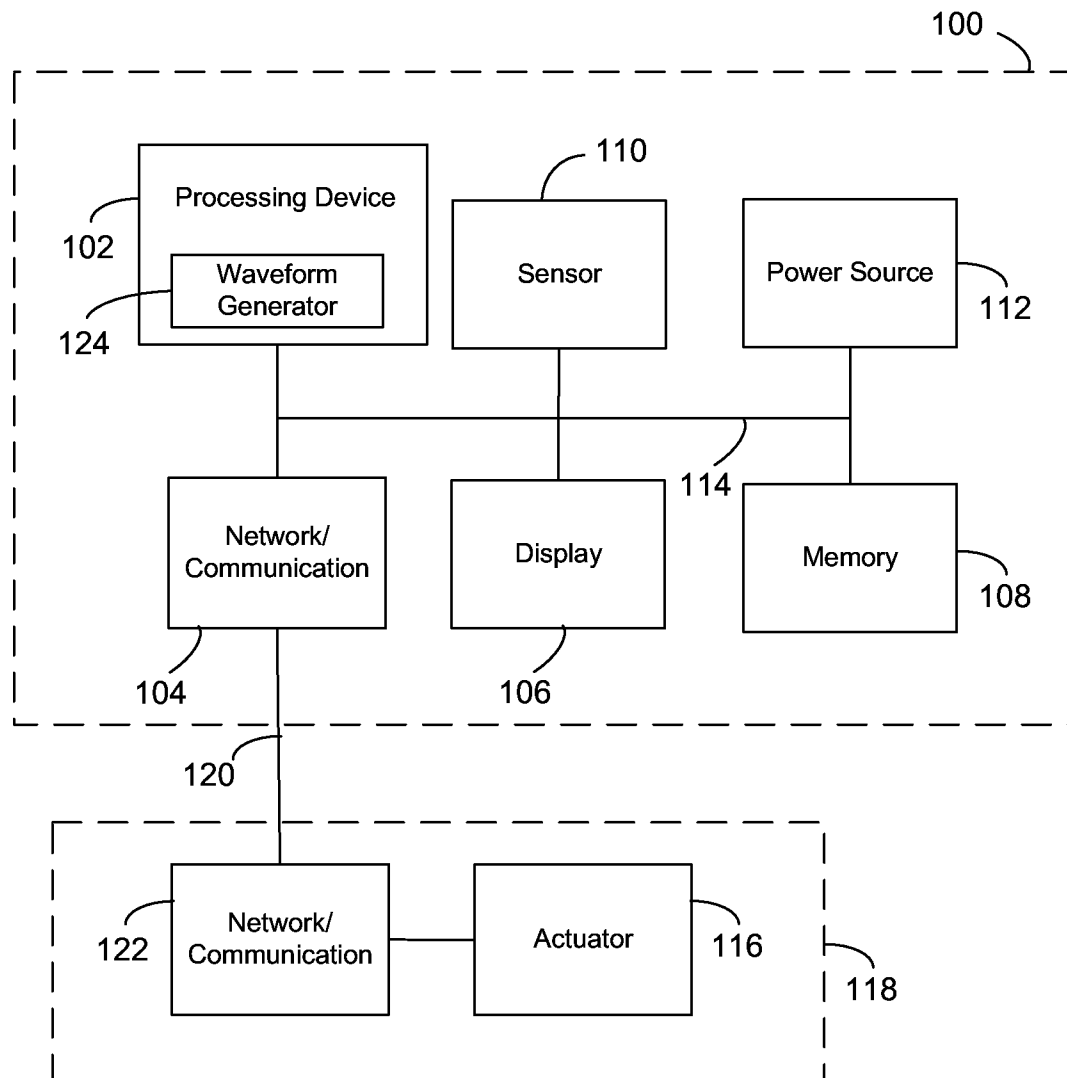


FIG. 1

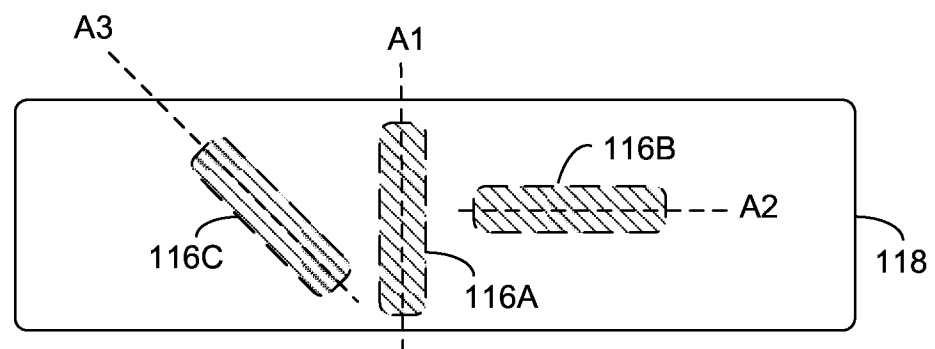


FIG. 2

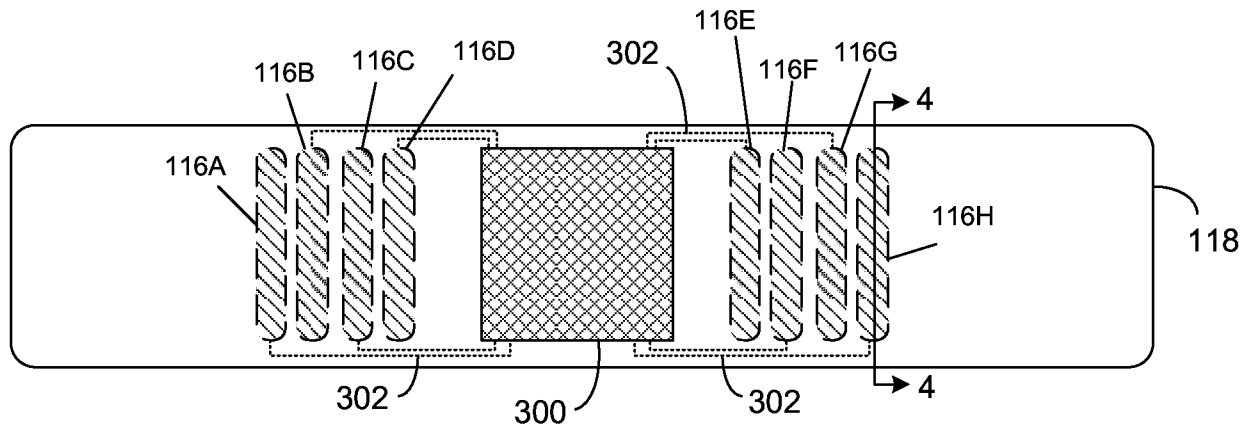


FIG. 3

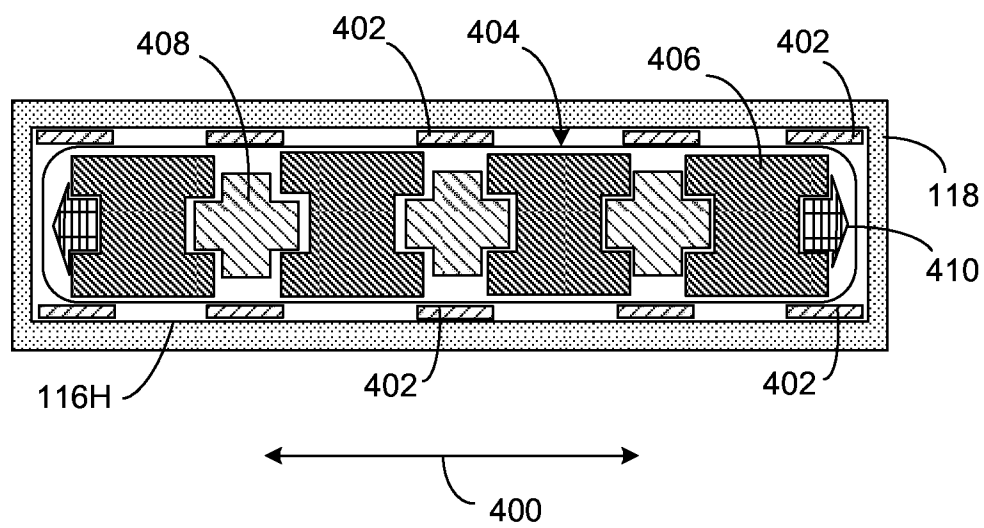


FIG. 4

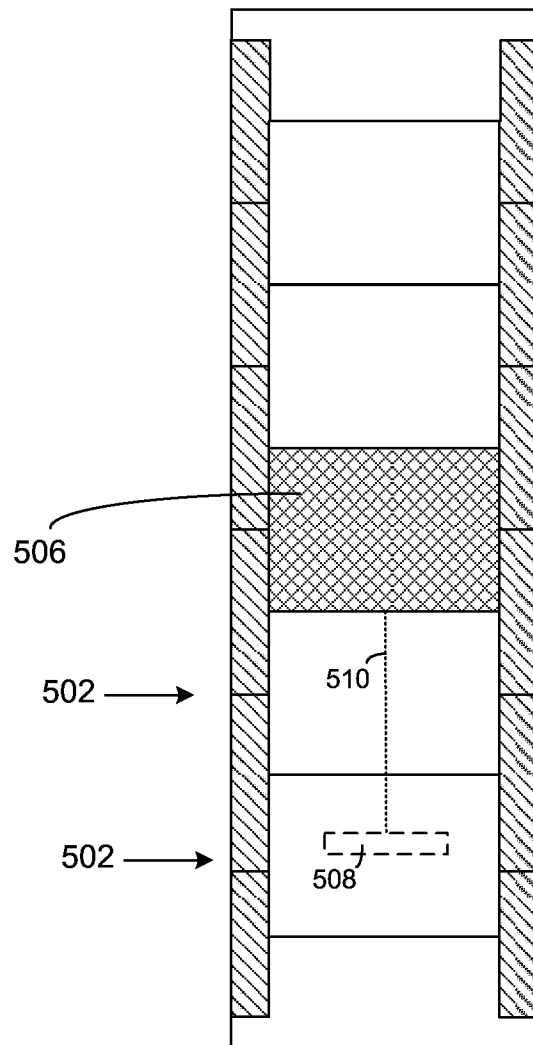


FIG. 5

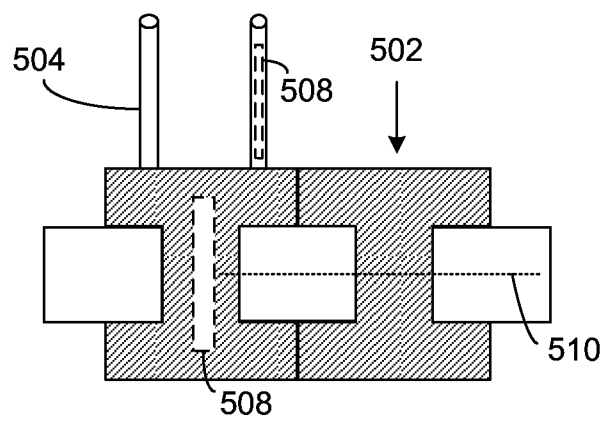


FIG. 6

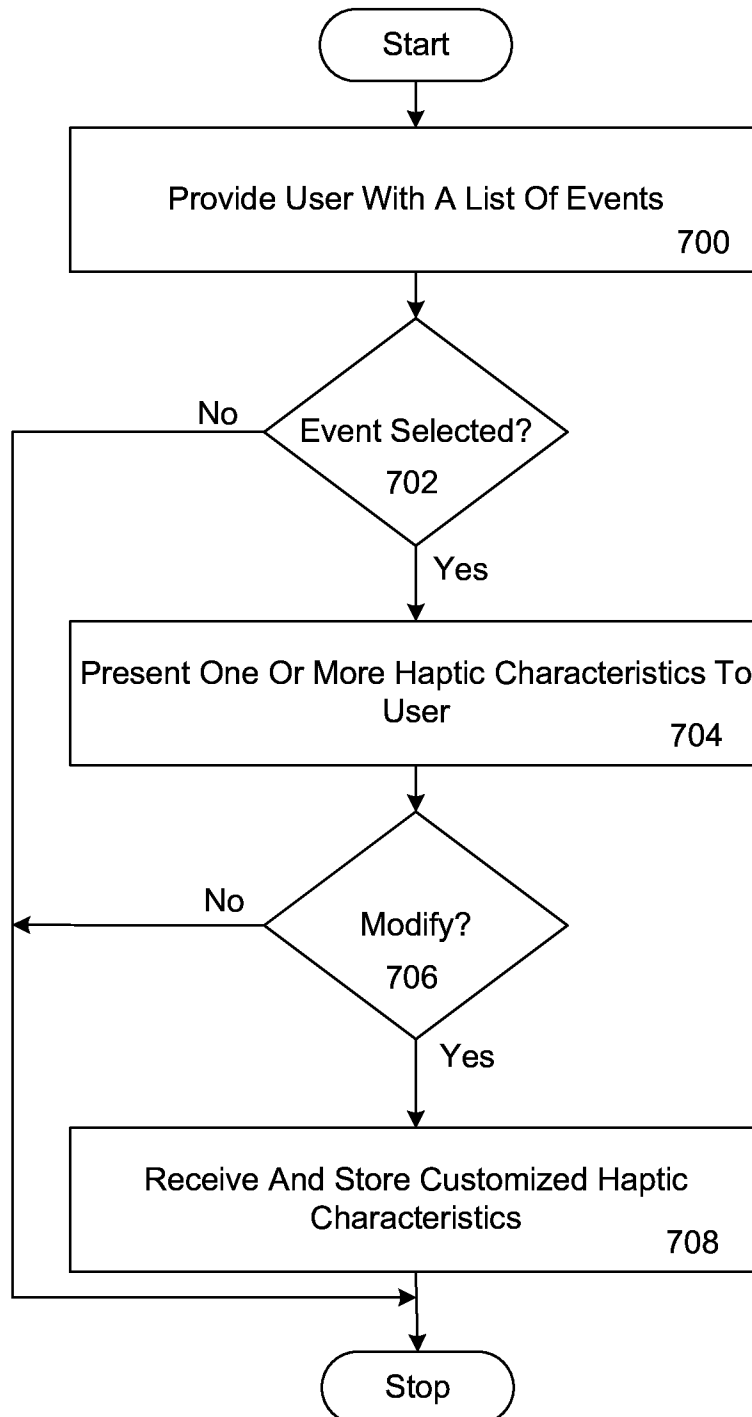


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/062488

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F3/01
ADD.

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)
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)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2009/167677 A1 (KRUSE BARBARA [US] ET AL) 2 July 2009 (2009-07-02) paragraphs [0006], [0018] - [0020], [0026], [0027], [0034] -----	1-16
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A	EP 2 461 228 A2 (IMMERSION CORP [US]) 6 June 2012 (2012-06-06) paragraphs [0005], [0019] -----	1-16

☐

Further documents are listed in the continuation of Box C.

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See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/062488

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