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(54) TERMINAL AND STORAGE MEDIUM

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(57) ABSTRACT

A portable terminal for controlling an apparatus includes: a display with a touchscreen; a vibrator that is configured to perform a vibration action of vibrating at least an operation surface of the touchscreen; and a hardware processor that determines whether or not the terminal is in a placed state of being placed on an object and causes the vibrator to perform the vibration action in response to a touch operation on the operation surface. When the terminal is in the placed state, the hardware processor causes the vibrator to perform the vibration action at first vibration intensity. When the terminal is not in the placed state, the hardware processor causes the vibrator to perform the vibration action at second vibration intensity that is lower than the first vibration intensity.

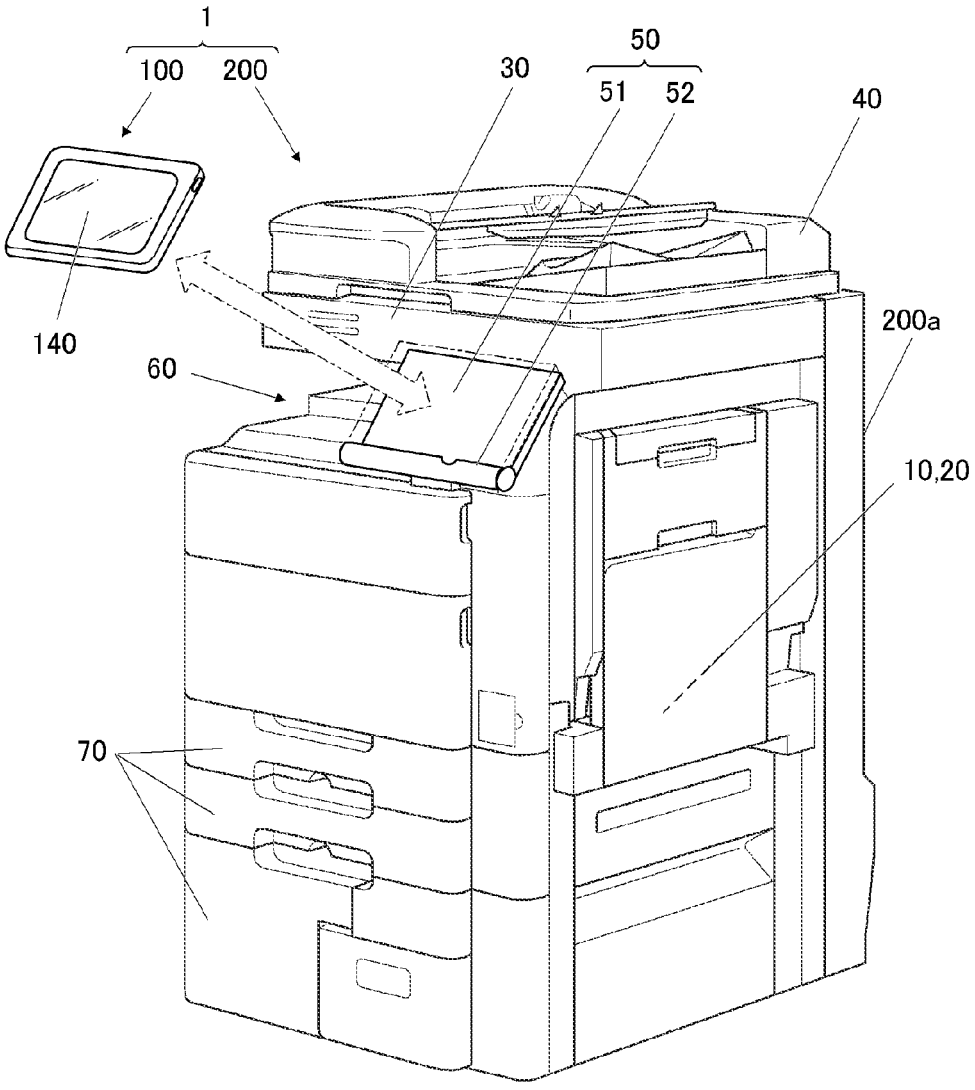


FIG.1

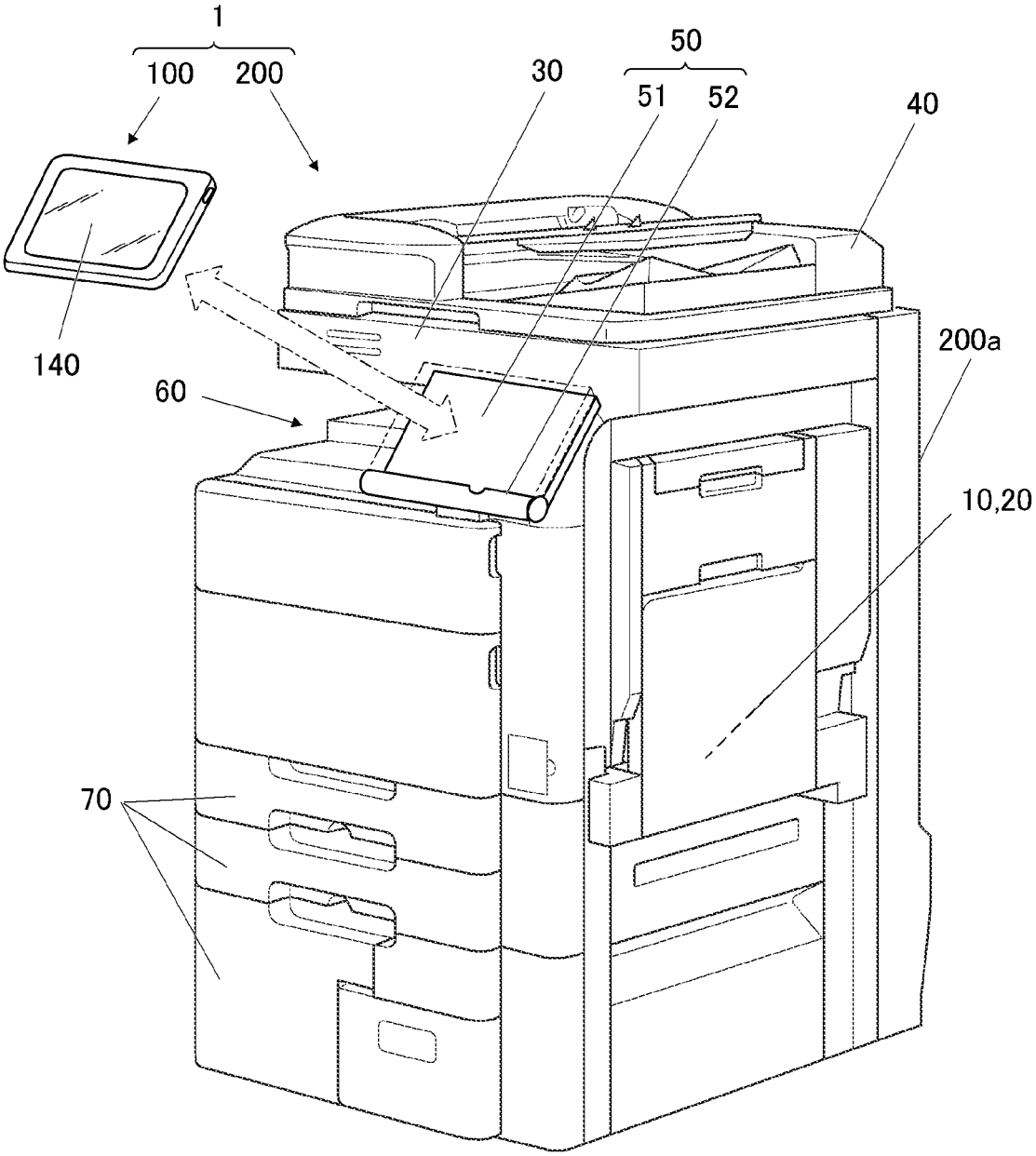


FIG.2

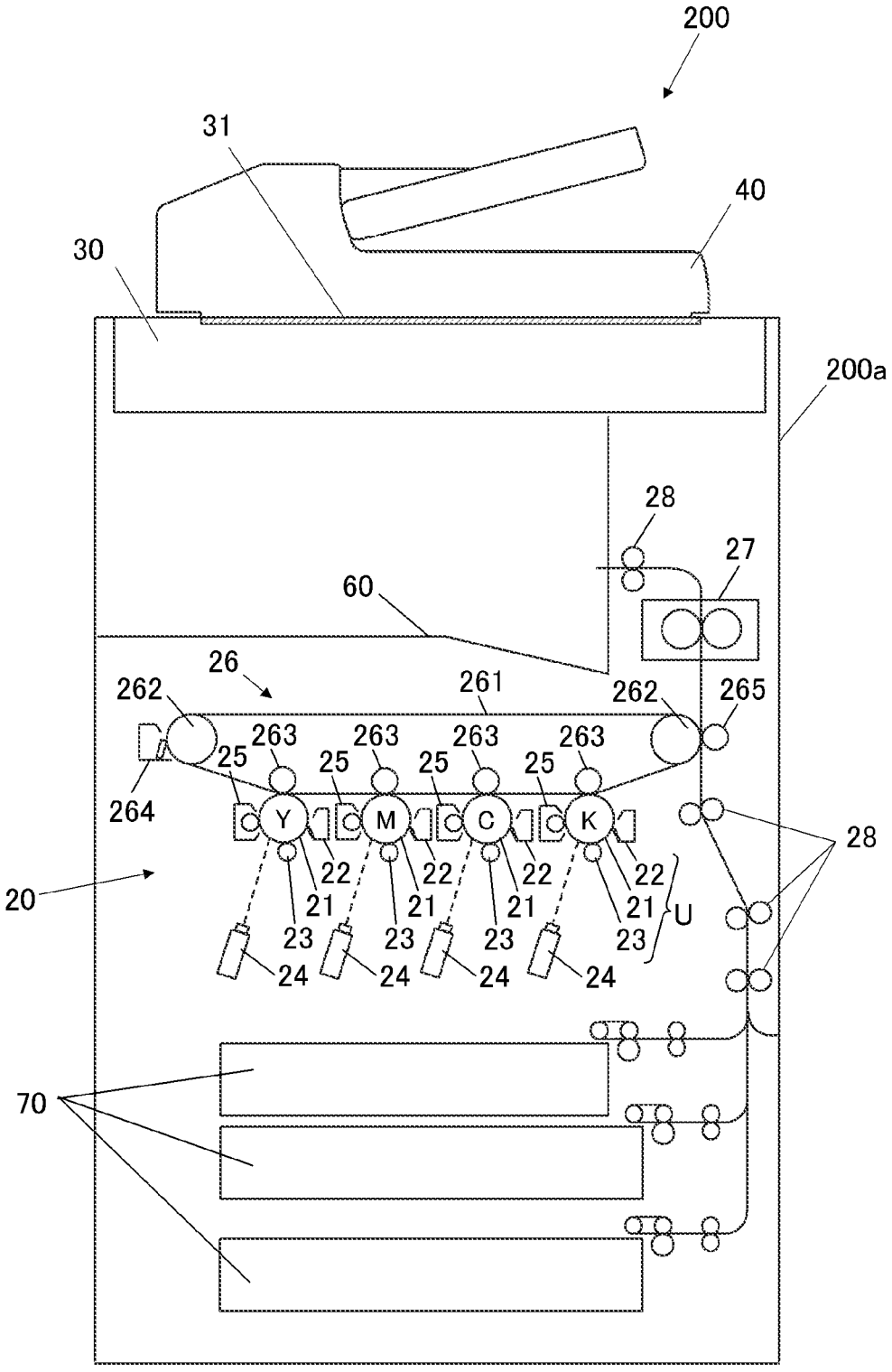

200
31
40
30
200a
28
27
60
26
262
261
262
265
263
263
263
263
25
25
25
25
264
Y
M
C
K
28
22
22
22
22
21
21
21
21
U
23
23
23
23
24
24
24
24
20
70

FIG.3

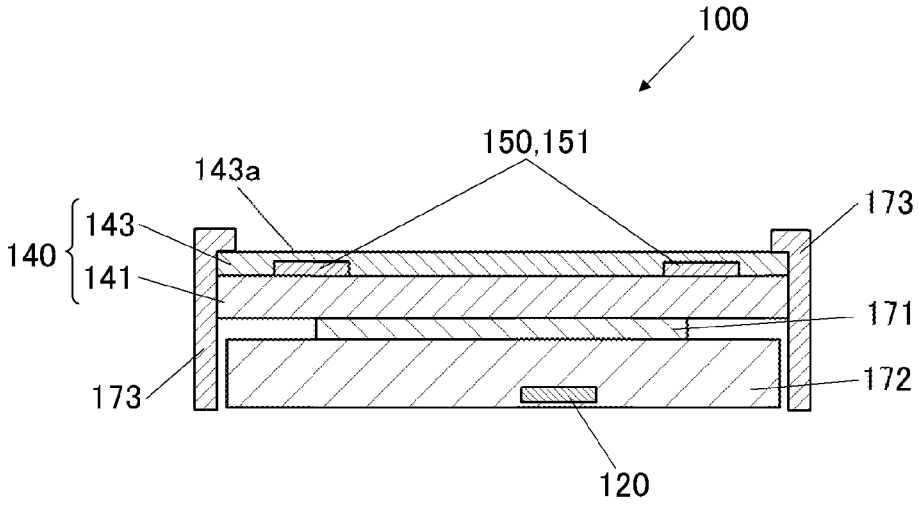

100
150,151
143a
140
143
141
173
171
172
173
120

FIG.4

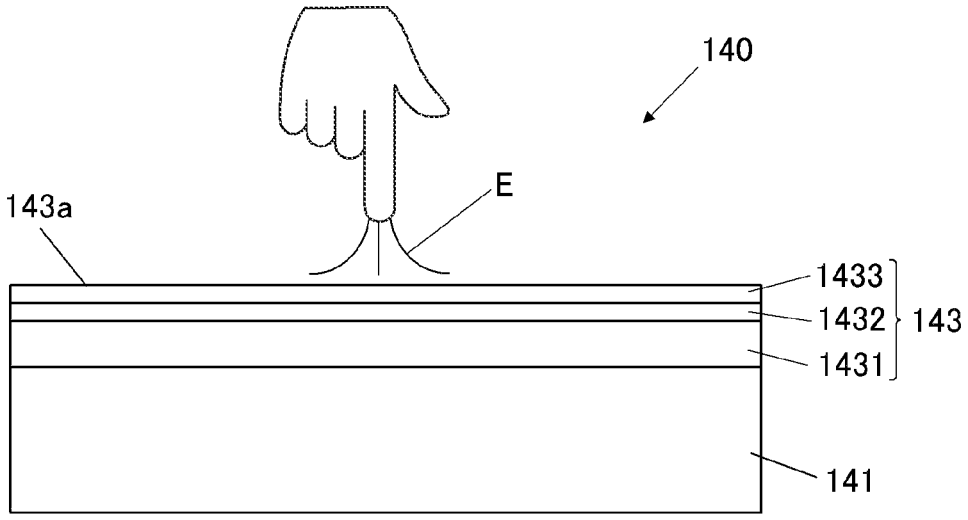

140
E
143a
1433
1432
143
1431
141

FIG.5

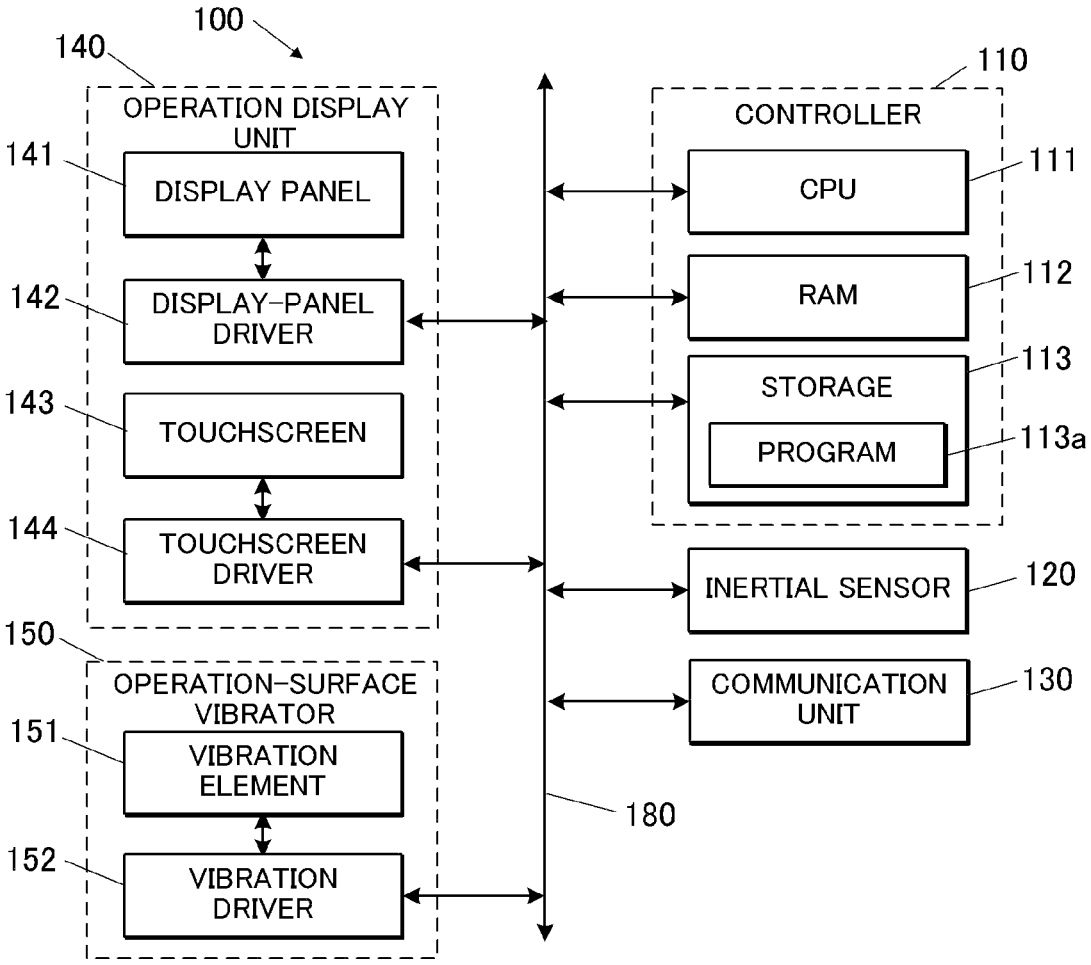

100
140
OPERATION DISPLAY UNIT
141
DISPLAY PANEL
142
DISPLAY-PANEL DRIVER
143
TOUCHSCREEN
144
TOUCHSCREEN DRIVER
150
OPERATION-SURFACE VIBRATOR
151
VIBRATION ELEMENT
152
VIBRATION DRIVER
110
CONTROLLER
111
CPU
112
RAM
113
STORAGE
PROGRAM
113a
120
INERTIAL SENSOR
130
COMMUNICATION UNIT
180

FIG.6

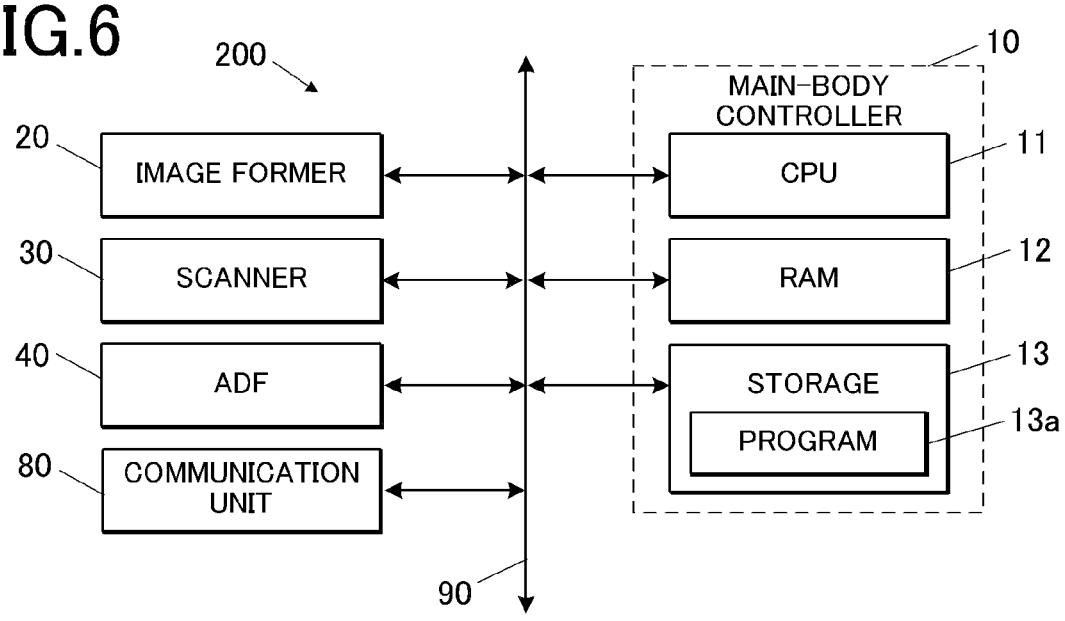

200
20
IMAGE FORMER
30
SCANNER
40
ADF
80
COMMUNICATION UNIT
90
10
MAIN-BODY CONTROLLER
11
CPU
12
RAM
13
STORAGE
PROGRAM
13a

FIG.7

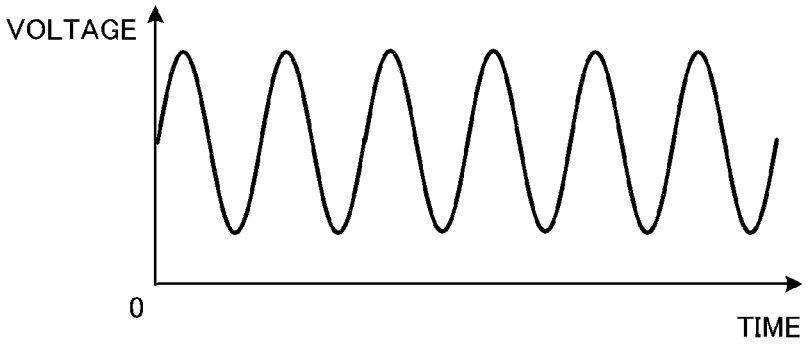


FIG.8

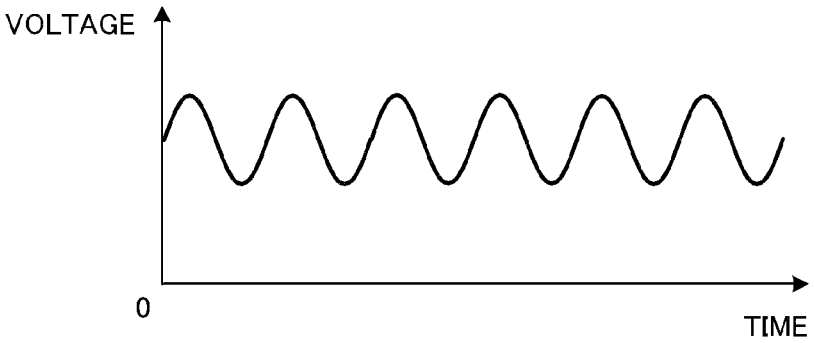


FIG.9

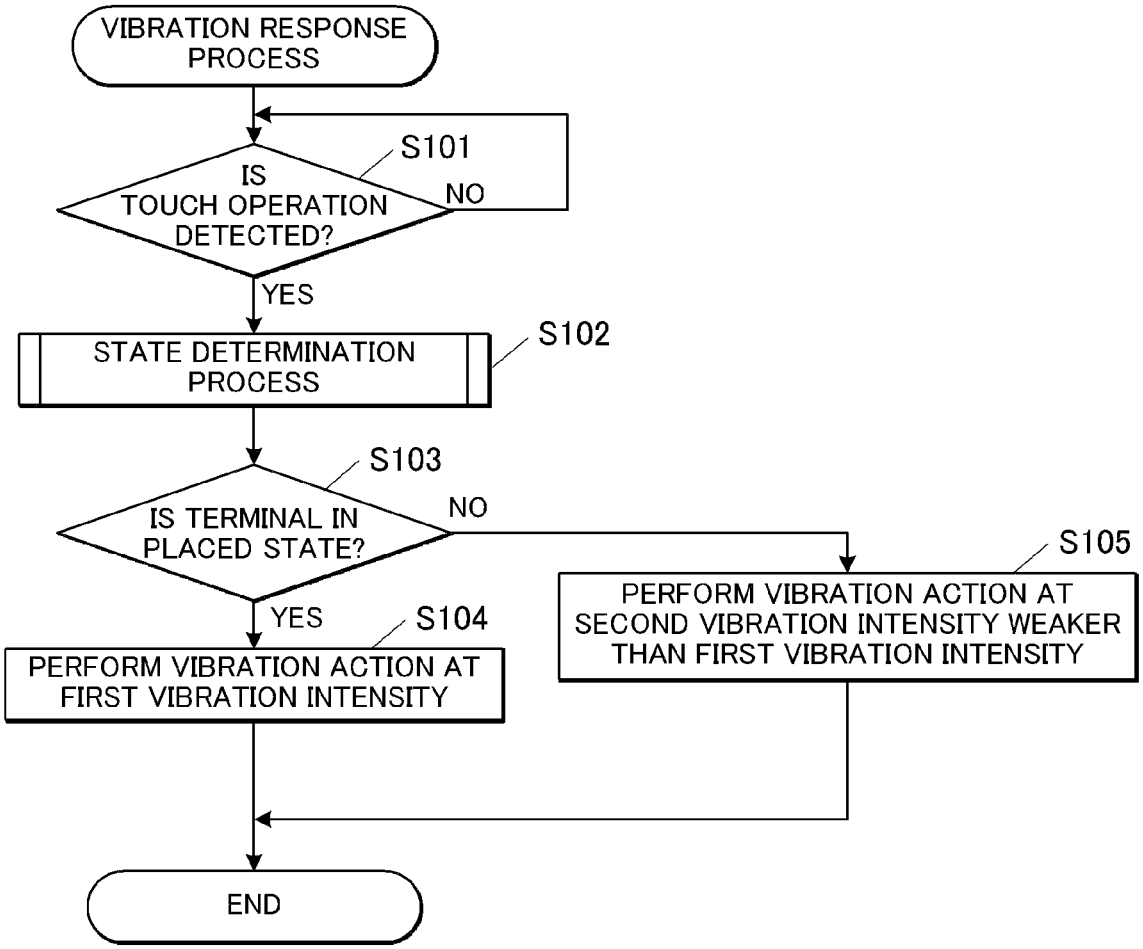

VIBRATION RESPONSE PROCESS
S101
IS TOUCH OPERATION DETECTED?
NO
YES
STATE DETERMINATION PROCESS
S102
S103
IS TERMINAL IN PLACED STATE?
NO
YES
S104
PERFORM VIBRATION ACTION AT FIRST VIBRATION INTENSITY
S105
PERFORM VIBRATION ACTION AT SECOND VIBRATION INTENSITY WEAKER THAN FIRST VIBRATION INTENSITY
END

FIG.10

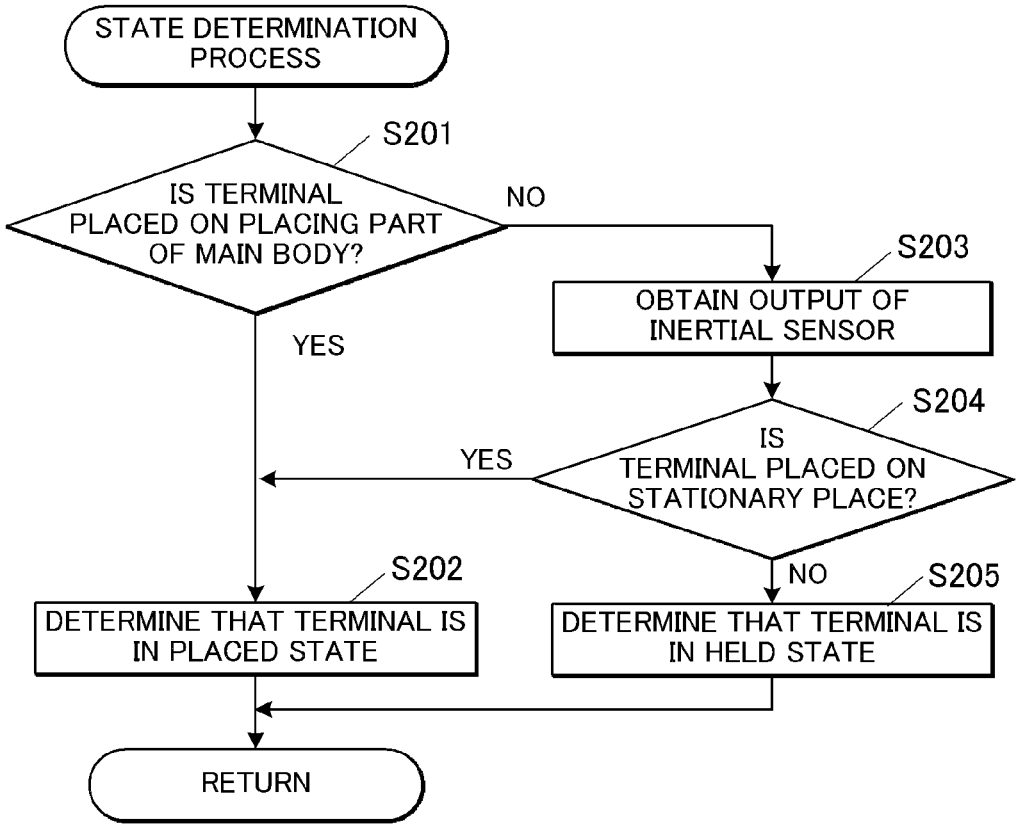

STATE DETERMINATION PROCESS
S201
IS TERMINAL PLACED ON PLACING PART OF MAIN BODY?
NO
YES
S203
OBTAIN OUTPUT OF INERTIAL SENSOR
S204
IS TERMINAL PLACED ON STATIONARY PLACE?
YES
NO
S202
DETERMINE THAT TERMINAL IS IN PLACED STATE
S205
DETERMINE THAT TERMINAL IS IN HELD STATE
RETURN

FIG.11

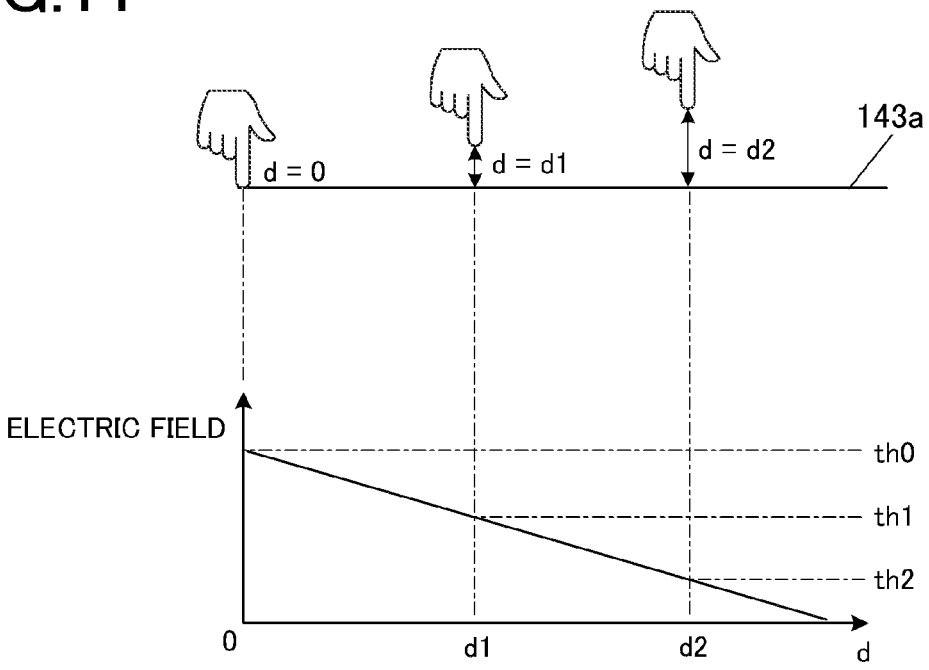

d = 0
d = d1
d = d2
143a
ELECTRIC FIELD
th0
th1
th2
0
d1
d2
d

FIG.12

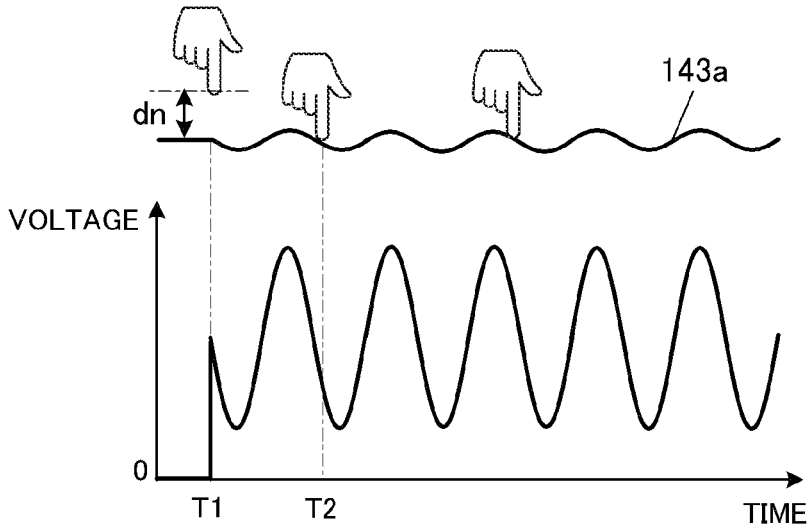


FIG.13

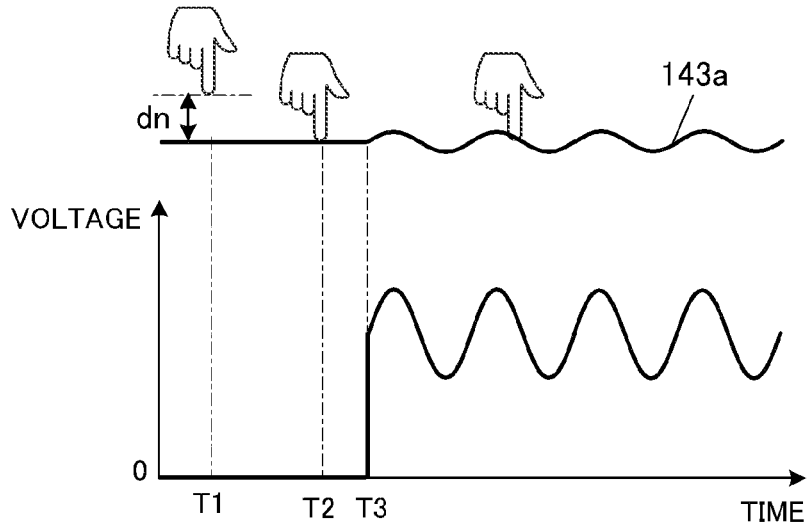


FIG.14

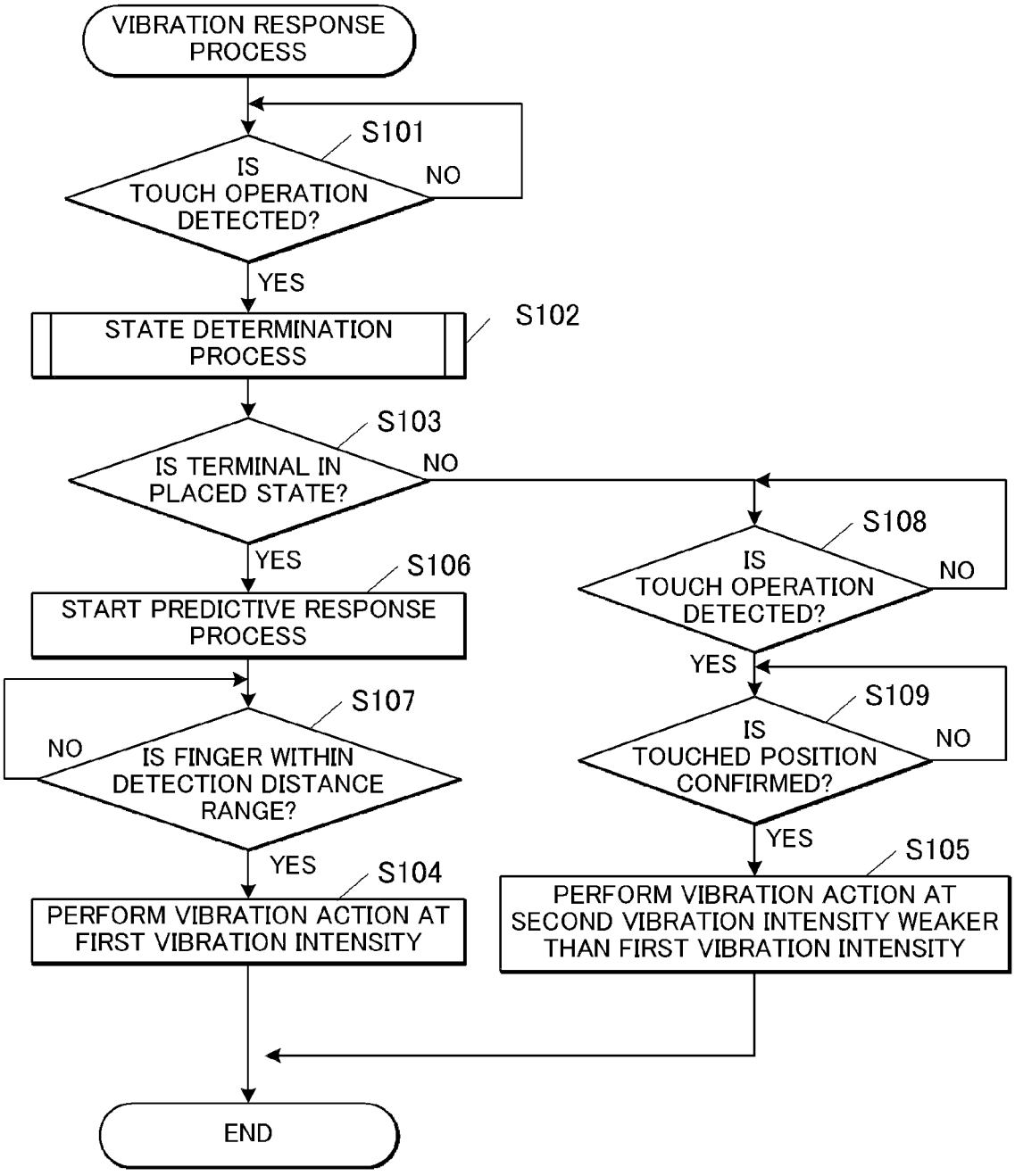

VIBRATION RESPONSE PROCESS
S101
IS TOUCH OPERATION DETECTED?
NO
YES
STATE DETERMINATION PROCESS
S102
S103
IS TERMINAL IN PLACED STATE?
NO
YES
S106
START PREDICTIVE RESPONSE PROCESS
S107
NO
IS FINGER WITHIN DETECTION DISTANCE RANGE?
YES
S104
PERFORM VIBRATION ACTION AT FIRST VIBRATION INTENSITY
S108
IS TOUCH OPERATION DETECTED?
NO
YES
S109
IS TOUCHED POSITION CONFIRMED?
NO
YES
S105
PERFORM VIBRATION ACTION AT SECOND VIBRATION INTENSITY WEAKER THAN FIRST VIBRATION INTENSITY
END

FIG.15

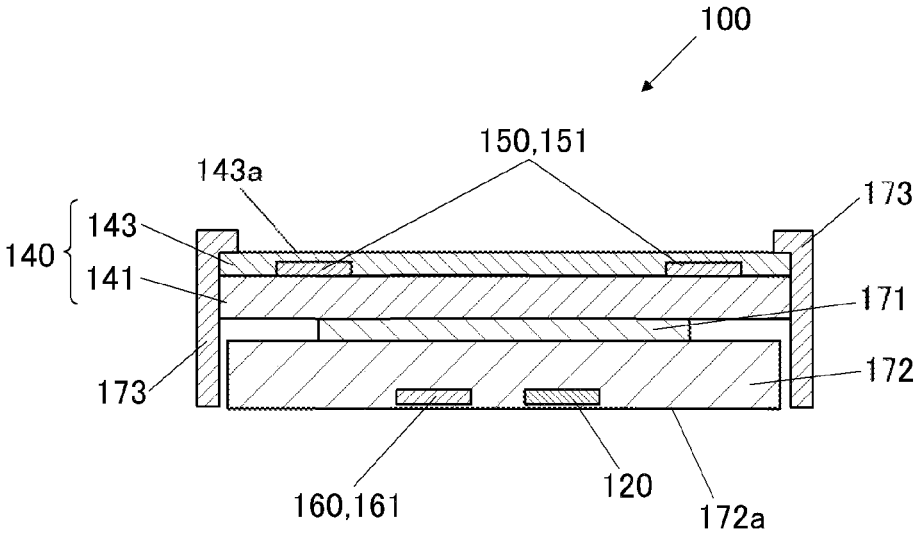


FIG.16

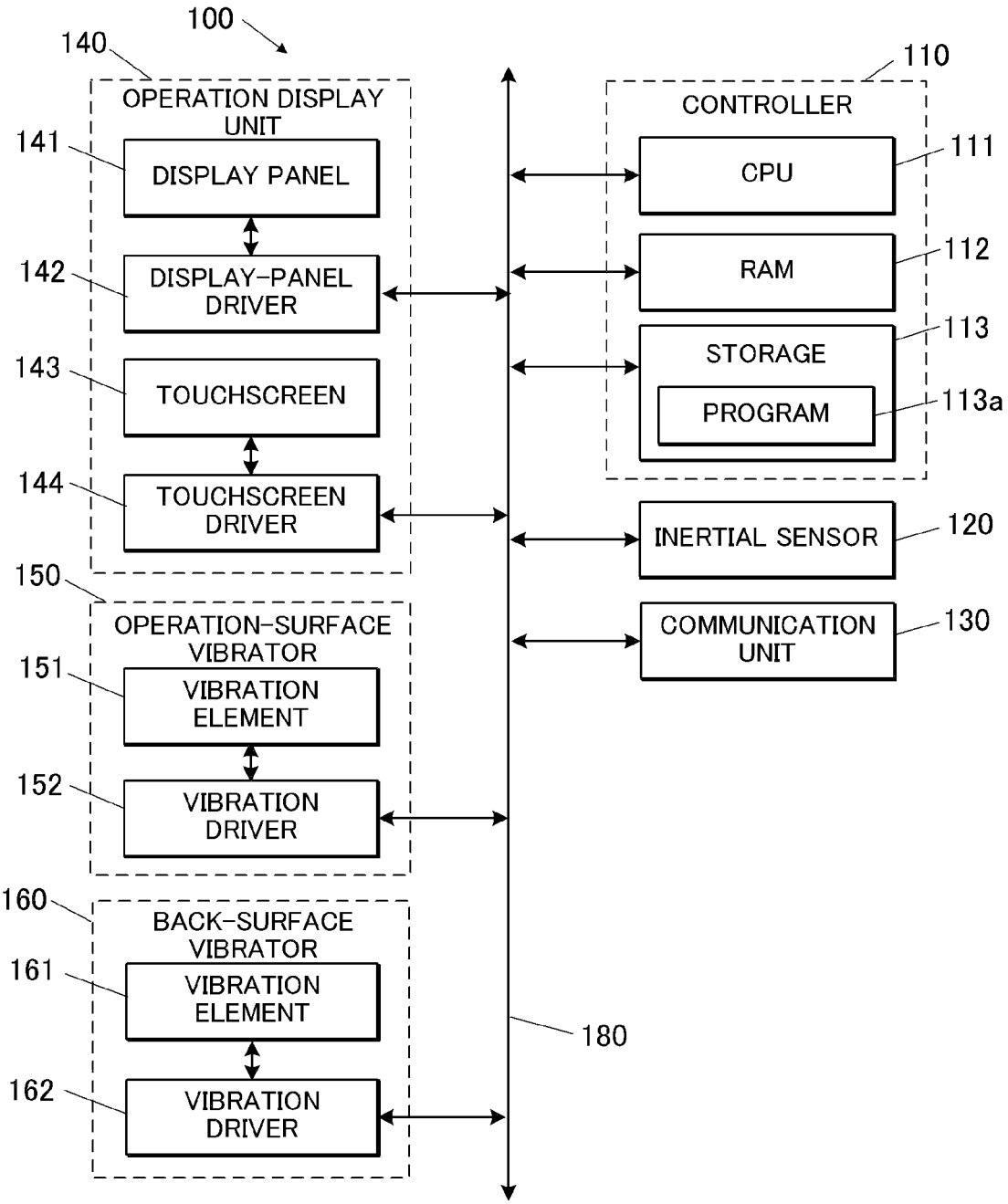
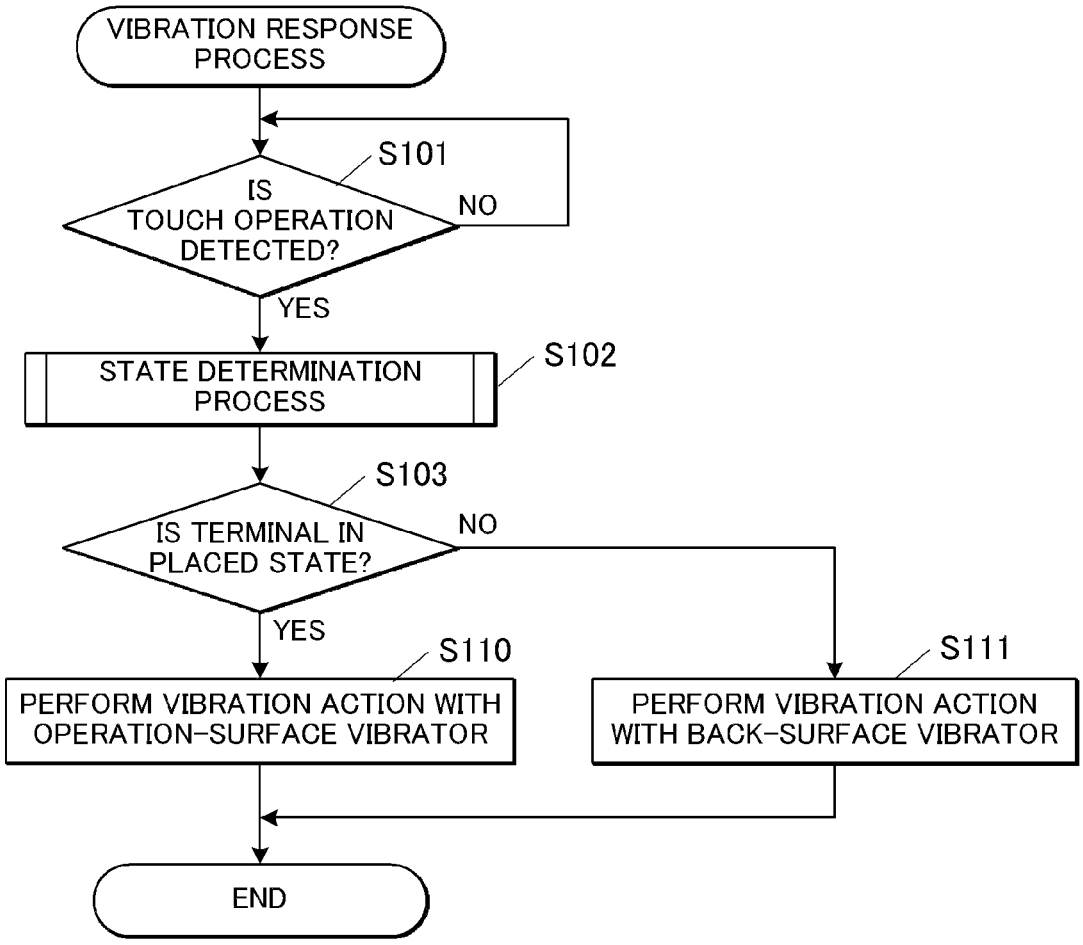

100
140
OPERATION DISPLAY UNIT
141
DISPLAY PANEL
142
DISPLAY-PANEL DRIVER
143
TOUCHSCREEN
144
TOUCHSCREEN DRIVER
150
OPERATION-SURFACE VIBRATOR
151
VIBRATION ELEMENT
152
VIBRATION DRIVER
160
BACK-SURFACE VIBRATOR
161
VIBRATION ELEMENT
162
VIBRATION DRIVER
180
110
CONTROLLER
CPU
111
RAM
112
STORAGE
113
PROGRAM
113a
INERTIAL SENSOR
120
COMMUNICATION UNIT
130

FIG.17


VIBRATION RESPONSE PROCESS
S101
IS TOUCH OPERATION DETECTED?
NO
YES
STATE DETERMINATION PROCESS
S102
S103
IS TERMINAL IN PLACED STATE?
NO
YES
S110
PERFORM VIBRATION ACTION WITH OPERATION-SURFACE VIBRATOR
S111
PERFORM VIBRATION ACTION WITH BACK-SURFACE VIBRATOR
END

TERMINAL AND STORAGE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The entire disclosure of Japanese Patent Application No. 2020-119608 filed on Jul. 13, 2020 is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to a terminal and a storage medium.

BACKGROUND

[0003] A stationary image forming apparatus, such as a multifunctional peripheral, may include a terminal that is detachable from the main body of the apparatus and that sends a control signal to the apparatus for operating the apparatus in response to receiving an input operation. A common type of such a terminal has a display for displaying the operation window and detects a touch operation made on the operation surface of the touchscreen of the display as an input operation. Further, according to JP2017-130030A, a terminal includes a vibrator that vibrates the terminal in response to a touch operation received on the operation surface (vibration response).

SUMMARY

[0004] However, the terminal may be in various states when receiving the touch operation. For example, the terminal may be mounted on the main body of the apparatus or may be held in the hand of a user (operator). Depending on the state of the terminal, the user may touch different parts of the terminal for different periods of time and may not perceive a vibration response. More specifically, depending on the state of the terminal, the vibration response may be too week to feel or may be too strong and annoying.

[0005] The known art has not taken into account whether or not the vibration response is perceivable to the user, and therefore may not provide an appropriate vibration response to the user.

[0006] Objects of the present invention include providing a terminal and a storage medium storing a program that can give more appropriate vibration responses to the user.

[0007] To achieve at least one of the abovementioned objects, according to an aspect of the present invention, there is provided a portable terminal for controlling an apparatus, including: a display with a touchscreen; a vibrator that is configured to perform a vibration action of vibrating at least an operation surface of the touchscreen; and a hardware processor that determines whether or not the terminal is in a placed state of being placed on an object and causes the vibrator to perform the vibration action in response to a touch operation on the operation surface, wherein when the terminal is in the placed state, the hardware processor causes the vibrator to perform the vibration action at first vibration intensity, and when the terminal is not in the placed state, the hardware processor causes the vibrator to perform the vibration action at second vibration intensity that is lower than the first vibration intensity.

[0008] According to another aspect of the present invention, there is provided a portable terminal for controlling an apparatus, including: a display with a touchscreen; a vibrator that is configured to perform a vibration action of vibrating at least an operation surface of the touchscreen; and a hardware processor that controls the vibration action of the vibrator, determines whether or not the terminal is in a placed state of being placed on an object, makes a prediction on whether a touch operation is to be performed on the operation surface by detecting an operation tool approaching the operation surface within a certain distance, and detects the touch operation performed on the operation surface with the operation tool, wherein when the terminal is in the placed state, the hardware processor causes the vibrator to start the vibration action in response to predicting the touch operation, and when the terminal is not in the placed state, the hardware processor causes the vibrator to start the vibration action in response to detecting the touch operation.

[0009] According to another aspect of the present invention, there is provided a portable terminal for controlling an apparatus, including: a display with a touchscreen; a first vibrator that is configured to perform a first vibration action of vibrating an operation surface of the touchscreen; a second vibrator that is configured to perform a second vibration action of vibrating a surface of the terminal opposite the operation surface; and a hardware processor that controls the first vibration action by the first vibrator and the second vibration action by the second vibrator and determines whether or not the terminal is in a placed state of being placed on an object, wherein when the terminal is in the placed state, the hardware processor causes the first vibrator to perform the first vibration action in response to a touch operation on the operation surface, and when the terminal is not in the placed state, the hardware processor causes the second vibrator to perform the second vibration action in response to the touch operation on the operation surface.

[0010] According to another aspect of the present invention, there is provided a non-transitory computer-readable storage medium storing a program that causes a computer of a portable terminal, the terminal being for controlling an apparatus and including a display with a touchscreen and a vibrator that is configured to perform a vibration action of vibrating at least an operation surface of the touchscreen, to function as a hardware processor that: determines whether or not the terminal is in a placed state of being placed on an object; and causes the vibrator to perform the vibration action in response to a touch operation on the operation surface, wherein when the terminal is in the placed state, the hardware processor causes the vibrator to perform the vibration action at first vibration intensity, and when the terminal is not in the placed state, the hardware processor causes the vibrator to perform the vibration action at second vibration intensity that is lower than the first vibration intensity.

[0011] According to another aspect of the present invention, there is provided a non-transitory computer-readable storage medium storing a program that causes a computer of a portable terminal, the terminal being for controlling an apparatus and including a display with a touchscreen and a vibrator that is configured to perform a vibration action of vibrating at least an operation surface of the touchscreen, to function as a hardware processor that: controls the vibration action of the vibrator; determines whether or not the terminal is in a placed state of being placed on an object; makes a prediction on whether a touch operation is to be performed on the operation surface by detecting an operation tool approaching the operation surface within a certain distance; and detects the touch operation performed on the operation

surface with the operation tool, wherein when the terminal is in the placed state, the hardware processor causes the vibrator to start the vibration action in response to predicting the touch operation, and when the terminal is not in the placed state, the hardware processor causes the vibrator to start the vibration action in response to detecting the touch operation.

[0012] According to another aspect of the present invention, there is provided a non-transitory computer-readable storage medium storing a program that causes a computer of a portable terminal, the terminal being for controlling an apparatus and including: a display with a touchscreen; a first vibrator that is configured to perform a first vibration action of vibrating an operation surface of the touchscreen; and a second vibrator that is configured to perform a second vibration action of vibrating a surface of the terminal opposite the operation surface, to function as a hardware processor that: controls the first vibration action by the first vibrator and the second vibration action by the second vibrator; and determines whether or not the terminal is in a placed state of being placed on an object, wherein when the terminal is in the placed state, the hardware processor causes the first vibrator to perform the first vibration action in response to a touch operation on the operation surface, and when the terminal is not in the placed state, the hardware processor causes the second vibrator to perform the second vibration action in response to the touch operation on the operation surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The advantages and features provided by one or more embodiments of the invention will become more fully understood from the detailed description given hereinbelow and the appended drawings which are given by way of illustration only, and thus are not intended as a definition of the limits of the present invention, wherein:

[0014] FIG. **1** is a schematic configuration of an image forming apparatus in a first embodiment;

[0015] FIG. **2** is a configuration of an image former;

[0016] FIG. **3** is a sectional view of a configuration of a terminal;

[0017] FIG. **4** is a sectional view of a detailed configuration of an operation display unit;

[0018] FIG. **5** is a block diagram showing main functional components of the terminal;

[0019] FIG. **6** is a block diagram showing main functional components of the main body of the image forming apparatus;

[0020] FIG. **7** shows a first driving waveform to be applied to a vibration element when the terminal is in a placed state;

[0021] FIG. **8** shows a second driving waveform to be applied to the vibration element when the terminal is in a held state;

[0022] FIG. **9** is a flowchart showing control steps of a vibration response process in the first embodiment;

[0023] FIG. **10** is a flowchart showing control steps of a state determination process;

[0024] FIG. **11** is a figure to explain how a touchscreen detects the approach of a finger;

[0025] FIG. **12** shows a first driving waveform when a predictive response process is performed in a second embodiment;

[0026] FIG. **13** shows a second driving waveform in the second embodiment;

[0027] FIG. **14** is a flowchart showing control steps of the vibration response process in the second embodiment;

[0028] FIG. **15** is a sectional view of a configuration of the terminal in a third embodiment;

[0029] FIG. **16** is a block diagram showing main functional components of the terminal in the third embodiment; and

[0030] FIG. **17** is a flowchart showing control steps of the vibration response process in the third embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0031] Hereinafter, an embodiment of the present invention is described with reference to the drawings. However, the scope of the present invention is not limited to the disclosed embodiment.

First Embodiment

[0032] FIG. **1** is a schematic configuration of an image forming apparatus **1** in a first embodiment.

[0033] The image forming apparatus **1** in this embodiment is an electrophotographic multifunctional apparatus that forms color images. The image forming apparatus **1** has functions as a scanner, a color copier, and a laser printer.

[0034] As shown in FIG. **1**, the image forming apparatus **1** includes a main body **200** and a terminal **100** that is attachable to and detachable from the main body **200**.

[0035] The main body **200** includes: a housing **200***a*; a main-body controller **10** and an image former **20** housed in the housing **200***a*; a scanner **30**; an auto document feeder (ADF) **40**; a cradle part **50** on which the terminal **100** is placed and mounted and that is provided outside the housing **200***a*; a sheet receiver **60** that is exposed outside the housing **200***a* under the scanner **30**; and a sheet feeder **70** that can be opened to the front of the housing **200***a* and closed.

[0036] FIG. **2** is a configuration of the image former **20**.

[0037] The image former **20** forms images on a sheet of paper fed by the sheet feeder **70** and ejects the sheet to the sheet receiver **60** under the control of the main-body controller **10**.

[0038] The image former **20** includes: image carriers **21** each of which is a drum-type photoconductor that carries an electrostatic latent image(s) on its surface; cleaners **22** each of which removes residual toner on the surface of the corresponding image carrier **21**; charging rollers **23** each of which uniformly charges the surface of the corresponding image carrier **21**; exposing units **24** each of which forms the electrostatic latent image by exposing the surface of the charged corresponding image carrier **21**; developing units **25** each of which develops the electrostatic latent image and forms a toner image on the surface of the corresponding image carrier **21** by using a developer containing toner; a transfer unit **26** that transfers the formed toner images onto an intermediate transfer belt **261** in the transferring region as the first transfer and that transfers the YMCK toner image on the intermediate transfer belt **261** onto a sheet as the second transfer; a fixing unit **27** that fixes the YMCK toner image to the sheet; and conveying rollers **28** that convey the sheet on a conveying path from the sheet feeder **70** to the sheet receiver **60**. Among the above components, the image carrier **21**, the cleaner **22**, the charging roller **23**, the exposing unit **24**, and the developing unit **25** constitutes an imaging unit.

[0039] The image former **20** has four imaging units for colors of yellow (Y), magenta (M), cyan (C), and black (K). The imaging units are arranged in the order of Y, M, C, and K along the bottom plane surface of the intermediate transfer belt **261**. In each of the imaging units, the cleaner **22**, the charging roller **23**, the exposing unit **24**, and the developing unit **25** are arranged in this order along the outer circumferential surface of the image carrier **21**.

[0040] The image carrier **21** rotates on an axis. The image carrier **21** has a photosensitive layer on its outer circumferential surface.

[0041] The cleaner **22** has a plate-shaped cleaning blade formed of an elastic material. The cleaner **22** causes the cleaning blade to abut the surface of the image carrier **21**, so that foreign substances on the surface of the image carrier **21**, such as residual toner that has not been transferred to the intermediate transfer belt **261**, are removed.

[0042] The charging roller **23** is a cylindrical member. The charging roller **23** abuts the surface of the image carrier **21** and rotates on an axis in accordance with the rotation of the image carrier **21**. The charging roller **23** receives charge-driving voltage from a not-shown power source to uniformly charge the surface of the image carrier **21**.

[0043] The exposing unit **24** includes a laser diode (LD) as a light-emitting element. The exposing unit **24** irradiates, with laser light, the surface of the image carrier **21** charged by the charging roller **23** to form an electrostatic latent image on the image carrier **21**.

[0044] The developing unit **25** includes a developing sleeve (developing roller) that faces the surface of the image carrier **21**. The developing unit **25** supplies a developer containing toner, which is supplied from a not-shown toner bottle, to the surface of the developing sleeve that has a certain developing-bias potential, so that the toner in the developer on the surface of the developing sleeve is adhered to the electrostatic latent image on the surface of the image carrier **21**. The developing unit **25** thus forms a toner image on the surface of the image carrier **21**.

[0045] The transfer unit **26** includes: two belt-conveying rollers **262**; four first transfer rollers **263** positioned so as to face the respective image carriers **21**; the intermediate transfer belt **261** stretched around the belt-conveying rollers **262** and the first transfer rollers **263**; a belt cleaner **264** that removes residual toner on the intermediate transfer belt **261**; and a second transfer roller **265** that is pressed against one of the belt-conveying rollers **262** and that is driven to rotate as the belt-conveying roller **262** rotates.

[0046] The transfer unit **26** transfers toner on the surface of the rotating image carriers **21** onto the intermediate transfer belt **261** by rotally moving the intermediate transfer belt **261** while applying, to the first transfer rollers **263**, bias voltage having a polarity reverse to the polarity of the toner. After transferring the Y, M, C, and K toner images such that the toner images are superposed on one another on the intermediate transfer belt **261**, the transfer unit **26** transfers the YMCK color toner image from the intermediate transfer belt **261** onto the sheet that passes through between the intermediate transfer belt **261** and the second transfer roller **265** to which predetermined bias voltage is applied. The residual toner on the intermediate transfer belt **261** that has not been transferred onto the sheet is removed by the cleaning blade of the belt cleaner **264**.

[0047] The fixing unit **27** heats and pressurizes the sheet on which the YMCK toner image has been transferred to fix the toner image to the sheet. The fixing unit **27** includes a pair of rollers constituted of a heating roller and a pressurizing roller to hold the sheet. The sheet to which the toner image has been fixed is conveyed by the conveying rollers **28** to the sheet receiver **60**.

[0048] The scanner **30** includes; a platen glass **31** that has a placing surface on which a sheet is placed; an optical system that includes, for example, a light source and a reflective mirror to irradiate the sheet on the platen glass **31**; and an imaging element that detects the light emitted by the optical system and reflected by the sheet. The scanner **30** reads an image on the sheet placed on the platen glass **31**, generates bitmapped image data for the respective colors of red (R), green (G), and blue (B), and stores the data in the storage **13** shown in FIG. **6** under the control of the main-body controller **10**.

[0049] The ADF **40** is provided above the scanner **30**. The ADF **40** includes a conveying mechanism that conveys manually-fed sheets one by one so that the scanner **30** scans the sheets. The ADF **40** is movable by the user within its movable range between the state of covering the platen glass **31** and the state of exposing the platen glass **31**.

[0050] The cradle part **50** shown in FIG. **1** is a cradle on which the terminal **100** is placed and mounted. The cradle part **50** has a placing surface **51** that supports the back of the terminal **100** and a supporter **52** that supports the bottom edge surface of the terminal **100**. The supporter **52** is provided with a connecting terminal for exchanging signals with the terminal **100** and for supplying power to the terminal **100**. When the terminal **100** is placed and mounted on the supporter **52**, the connecting terminal of the terminal **100** is electrically connected to the connecting terminal of the supporter **52**.

[0051] The sheet receiver **60** is provided under the scanner **30** and exposed to the outside of the housing **200***a*. The sheets on which images have been formed by the image former **20** are ejected to the sheet receiver **60** such that the user can take the sheets.

[0052] The sheet feeder **70** can be opened by being pulled towards the front of the housing **200***a* and can be closed. The sheet feeder **70** stores sheets on which images are to be formed.

[0053] The terminal **100** is a portable operation terminal for operating the main body **200**. The terminal **100** includes a controller **110** shown in FIG. **5** (hardware processor, computer) that is separate from the main-body controller **10** of the main body **200** and that controls the operation of the terminal **100**. The terminal **100** functions as the operation display unit **140** of the main body **200** both in the placed state of being placed on the cradle part **50** of the main body **200** and in the held state of being detached from the cradle part **50** and held by the user. In the placed state on the cradle part **50**, the terminal **100** operates with power supplied via the connecting terminal of the supporter **52**. When detached from the cradle part **50**, the terminal **100** operates with power of the built-in battery.

[0054] The terminal **100** includes the operation display unit **140** (display) that has a touchscreen. The terminal **100** displays, on the operation display unit **140**, an operation window for receiving input operations for operating the main body **200**, a status window for showing the status of the main body **200**, and so forth. The operation window shows, for example, operation buttons on which touching operations are performed via the touchscreen. When the touch-

screen detects a touch operation within a range of any of the operation buttons shown on the operation display unit **140**, the controller **110** determines that an input operation of selecting the operation button is performed and sends, to the main body **200**, a control signal to cause the main body **200** to perform a process associated with the operation button. When the terminal **100** is placed on the cradle part **50**, the control signal is sent via the connecting terminal of the supporter **52**. When the terminal **100** is detached from the cradle part **50**, the control signal is sent over a wireless communication, such as Bluetooth (registered trademark).

[0055] FIG. **3** is the sectional view of the configuration of the terminal **100**.

[0056] The terminal **100** includes the operation display unit **140**; an operation surface vibrator **150** (vibrator, first vibrator); an inertial sensor **120**; a vibration absorber **171**; a back casing **172**; and a lateral casing **173**.

[0057] The operation display unit **140** includes a display panel **141** and a touchscreen **143**.

[0058] The display panel **141** may be, for example, a liquid crystal display but is not limited thereto. The display panel **141** may be other types of display, such as an organic electroluminescent display. The display panel **141** is driven by a display-screen driver **142** in FIG. **5** to display the operation window, the status window, and so forth under the control of the controller **110**.

[0059] The touchscreen **143** is superimposed on and combined with the display panel **141**. The touchscreen **143** has an operation surface **143***a* that is laid on the display region of the display panel **141**. The touchscreen **143** detects a touch of an operating tool (e.g., the user's finger or a stylus) on the operation surface **143***a* and the touched position. In this embodiment, the touchscreen **143** detects the position touched by the operating tool on the basis of change in capacitance of the touchscreen **143**.

[0060] FIG. **4** is a sectional view of a detailed configuration of the operation display unit **140**.

[0061] The touchscreen **143** includes: a glass substrate **1431** placed on the display panel **141**; an electrode pattern layer **1432** placed on the glass substrate **1431**; and a protective cover **1433** placed on the electrode pattern layer **1432**. The surface of the protective cover **1433** constitutes the operation surface **143***a*.

[0062] The electrode pattern cover **1432** has the first layer, the second layer, and the insulative layer. In the first layer, first electrode wirings are arranged so as to extend in a first direction. In the second layer, second electrode wirings are arranged so as to extend in a second direction orthogonal to the first direction. The insulative layer is provided between the first and second layers. The first electrode wirings have transparent rectangular electrodes that are connected in the first direction, and the second electrode wirings have transparent rectangular electrodes that are connected in the second direction, for example.

[0063] When a finger approaches the operation surface **143***a*, the finger and part of the electrodes are capacitively coupled and generate an electric field E. According to the intensity of the electric field E, the capacitance between the electrodes changes. According to the change in capacitance, current flows through part of the first electrodes and part of the second electrodes. By calculating the ratio of current flowing through part of the first and second electrodes, the position (coordinate in the display region) touched with the finger can be identified.

[0064] Referring back to FIG. **3**, the operation-surface vibrator **150** has vibration elements **151** that convert electric signals into physical vibration. Each of the vibration elements **151** is placed on the touchscreen **143**-side surface of the display panel **141** so as not to overlap the display region of the display panel **141**. In FIG. **3**, one vibration element **151** is placed at each side of the display region of the display panel **141** as an example. The number and the position of vibration elements **151** are not limited to these shown in FIG. **3**. For example, the vibration elements **151** may be placed on the side opposite the touchscreen **143** of the display panel **141** (back surface of the display panel **141**).

[0065] The vibration elements **151** are vibrated by the vibration driver **152** shown in FIG. **5** under the control of the controller **110**. The vibration of the vibration elements **151** is transmitted to the operation surface **143***a* via the touchscreen **143**. When the use's finger (operating tool) touches the operation surface **143***a* that is receiving the vibration, the user feels the vibration as the vibration response from the operation display unit **140**. The operation-surface vibrator **150** including the vibration elements **151** thus performs the vibration action of vibrating the operation surface **143***a* of the touchscreen **143**.

[0066] The inertial sensor **120** includes: an acceleration sensor that detects the acceleration of the terminal **100**; and a gyro sensor that detects the angular velocity of the rotation of the terminal **100**. The inertial sensor **120** outputs the result of detecting the acceleration and the angular velocity to the controller **110**. On the basis of the detection result, the controller **110** determines whether the terminal **100** is placed on a stationary place (for example, the cradle part **50**) or is held and operated in the hand of the user.

[0067] The vibration absorber **171** is placed between the back surface of the display panel **141** of the operation display unit **140** and the back casing **172**. The vibration absorber **171** is a damper that absorbs the vibration of the display panel **141** that is generated by the vibration action of the operation-surface vibrator **150**. The vibration transmitting path from the back surface of the display panel **141** to the back casing **172** is set so as to pass through the vibration absorber **171**. This allows the vibration absorber **171** to efficiently prevent the vibration of the display panel **141** from being transmitted to the back casing **172**. Thus, when the terminal **100** is placed on an object, the vibration absorber **171** absorbs the vibration transmitted from the operation-surface vibrator **150** towards the place via the back casing **172**. The vibration absorber **171** may not completely absorb the vibration transmitted from the operation-surface vibrator **150** towards the place but may absorb at least part of the vibration. The material of the vibration absorber **171** is not limited to a specific material but may be an elastic resin, for example.

[0068] The back casing **172** is a box-shaped member that houses the controller **110**, the inertial sensor **120**, the display-panel driver **142**, the touchscreen driver **144**, and circuit elements constituting the vibration driver **152**. The internal configuration of the back casing **172** is not shown in FIG. **3**.

[0069] The lateral casing **173** is a plate-shaped member that covers the lateral sides of the display panel **141**, the touchscreen **143**, and the back casing **172**. The lateral sides of the display panel **141** and the touchscreen **143** are fixed to the lateral casing **173**. The lateral casing **173** has an opening part for exposing the operation surface **143***a* of the

touchscreen **143** to the outside. Through the opening part, the user can perform the touch operation on the exposed operation surface **143***a*. The lateral casing **173** also receives the vibration of the vibration elements **151** of the operation-surface vibrator **150** via the display panel **141** and the touchscreen **143**. Therefore, when the user detaches the terminal **100** from the cradle part **50** and holds it in his/her hand, the user can feel the vibration of the vibration elements **151** via the lateral casing **173** as well as via the operation surface **143***a*. In FIG. **3**, space is present between the lateral casing **173** and the back casing **172**. The space may be filled with the vibration absorber **171**.

[0070] FIG. **5** is a block diagram showing main functional components of the terminal **100**.

[0071] The terminal **100** includes the controller **110**, the inertial sensor **120**, the communication unit **130**, the operation display unit **140**, the operation-surface vibrator **150**, and a bus **180**. The operation display unit **140** includes the display panel **141**, the display-panel driver **142**, the touchscreen **143**, and the touchscreen driver **144**. The operation-surface vibrator **150** includes the vibration elements **151** and the vibration driver **152**. The components of the terminal **100** are connected via the bus **180**. The components that have already been described are not described below.

[0072] The controller **110** includes a central processing unit (CPU) **111**, a random access memory (RAM) **112**, and a storage **113**. The CPU **111** of the controller **110** executes the programs **113***a* stored in the storage **113** to perform various processes, so that the controller **110** functions as a vibration control unit, a state determination unit, a touch-operation prediction unit, and a touch-operation detection unit.

[0073] The CPU **111** reads and executes the programs **113***a* stored in the storage **113** to perform various arithmetic processes.

[0074] The RAM **112** provides a working memory space for the CPU **111** and stores temporal data.

[0075] The storage **113** consists of a nonvolatile storage, such as a hard disk drive (HDD), a solid state drive (SSD), and/or a flash memory. The storage **113** stores the programs **113***a* to be performed by the CPU **111** and various kinds of data.

[0076] The controller **110**, which includes the CPU **111**, the RAM **112**, and the storage **113**, centrally controls the components of the terminal **100** in accordance with the programs **113***a*.

[0077] For example, the controller **110** sends a control signal to the display-panel driver **142** to cause the display panel **141** to display the operation window and the status window.

[0078] Further, the controller **110** sends a control signal to the touchscreen driver **144** and receives a detection signal from the touchscreen driver **144** to detect the touch on the operation surface **143***a* of the touchscreen **143** with the operating tool and the touched position.

[0079] Further, the controller **110** sends a control signal to the vibration driver **152** to cause the vibration elements **151** to vibrate at an appropriate timing, intensity and vibration pattern.

[0080] The communication unit **130** is a communication module that includes an antenna, a modulation and demodulation circuit, and a signal processing circuit. The communication unit **130** wirelessly sends and receives data to and from the communication unit **80** of the main body **200** in accordance with a wireless communication protocol, such as Bluetooth.

[0081] FIG. **6** is a block diagram showing main functional components of the main body **200**.

[0082] The main body **200** includes the main-body controller **10**, the image former **20**, the scanner **30**, the ADF **40**, the communication unit **80**, and a bus **90**. The components of the main body **200** are connected via the bus **90**. The components that have already been described are not described below.

[0083] The main-body controller **10** includes a CPU **11**, a RAM **12**, and a storage **13**.

[0084] The CPU **11** reads and executes programs **13***a* stored in the storage **13** to perform various arithmetic processes.

[0085] The RAM **12** provides a working memory space for the CPU **11** and stores temporal data.

[0086] The storage **13** consists of a nonvolatile storage, such as a HDD, a SSD, and/or a flash memory. The storage **13** stores the programs **13***a* to be performed by the CPU **11** and various kinds of data. The kinds of data to be stored in the storage **13** include image data obtained by the scanner **30** and image data input from outside via the communication unit **80**.

[0087] The controller **10**, which includes the CPU **11**, the RAM **12**, and the storage **13**, centrally controls the components of the main body **200** in accordance with the programs **13***a*. For example, the controller **10** causes the components of the main body **200** to perform the operation corresponding to an input operation received by the terminal **100** in accordance with a control signal sent from the terminal **100** and received via the communication unit **80**.

[0088] The communication unit **80** consists of a network card, a communication module, and/or the like. The communication unit **80** is connected to a communication network, such as a local area network (LAN) to send and receive data to and from external apparatuses over the network. The communication unit **80** wirelessly sends and receives data to and from the communication unit **130** of the terminal **100** in accordance with the wireless communication protocol, such as Bluetooth.

[0089] Next, the operation of the image forming apparatus **1** is described. The description is mainly on the reception of an input operation with the terminal **100**.

[0090] The operation display unit **140** of the terminal **100** in this embodiment receives a touch operation on the operation surface **143***a* of the touchscreen **143** by the user as an input operation. The operation display unit **140** converts the input operation into an operation signal and outputs the operation signal to the controller **110**. The operation display unit **140** also sends a notification to the user in response to the received input operation by causing the operation-surface vibrator **150** to perform a vibration action (vibration response). More specifically, in response to the touch operation on the operation surface **143***a* being detected, the operation-surface vibrator **150** vibrates the vibration elements **151**. The vibration of the vibration elements **151** vibrates the operation surface **143***a* and the lateral casing **173**. The vibration of the operation surface **143***a* and the lateral casing **173** is received by the user as the vibration response.

[0091] When the touch operation is performed on the terminal **100** placed on an object (placed state), the vibration

of the operation surface **143***a* is transmitted to the finger of the user touching the operation surface **143***a*. The placed state may be a state in which the terminal **100** is placed on the cradle part **50** of the main body **200** or may be a state in which the terminal **100** is detached from the cradle part **50** and placed on a stationary place, such as a table. The object may not be stationary and may be, for example, a table set inside a moving vehicle. Examples of the object, however, do not include parts of the user's body (e.g., hand).

[0092] When the terminal **100** is in a state other than the placed state, namely in the non-placed state, the terminal **100** is operated in the hand of the user. The state of the terminal **100** other than the placed state is therefore called the held state. When the touch operation is performed on the operation surface **143***a* of the terminal **100** in the held state, the hand of the user is in contact with the lateral casing **173** as well as the operation surface **143***a*. The user therefore receives the vibration of the lateral casing **173** with his/her finger as well as the vibration response with his/her finger.

[0093] The vibration response in the placed state is transmitted only to the user's finger and is therefore less perceivable than the vibration response in the held state, which is transmitted to the user's hand.

[0094] When the intensity of the vibration response is increased so that the vibration response in the placed state is more perceivable to the user's finger, the vibration may be too strong for the user's hand holding the lateral casing **173**.

[0095] Vibrating the vibration elements **151** at uniform intensity therefore may not send an appropriate vibration response to the user.

[0096] To deal with the above issue, the controller **110** of the terminal **100** in this embodiment determines whether or not the terminal **100** is in the placed state, namely whether the terminal **100** is in the placed state or in the held state, and adjusts the vibration intensity of the operation-surface vibrator **150** according to the determination.

[0097] More specifically, when determining that the terminal **100** is in the placed state, the controller **110** causes the operation-surface vibrator **150** to perform the vibration action at first vibration intensity that can be felt by the finger. When determining that the terminal **100** is in the held state, the controller **110** causes the operation-surface vibrator **150** to perform the vibration action at second vibration intensity that is weaker than the first vibration intensity.

[0098] Accordingly, when the terminal **100** is in the placed state in which only the finger of the user is in contact with the terminal **100**, the terminal **100** performs vibration at appropriate and sufficient intensity so that the user easily feels the vibration. On the other hand, when the terminal **100** is in the held state in which both the finger and the hand of the user are in contact with the terminal **100**, the terminal **100** performs vibration at reduced intensity so as to avoid problems caused by too strong vibration and reduce power consumption by vibration.

[0099] FIG. **7** shows the voltage waveform (first driving waveform) of the driving signal to be applied to the vibration elements **151** when the terminal **100** in the placed state performs the vibration action at the first vibration intensity.

[0100] FIG. **8** shows the voltage waveform (second driving waveform) of the driving signal to be applied to the vibration elements **151** when the terminal **100** in the held state performs the vibration action at the second vibration intensity.

[0101] The first and second driving waveforms are both sine waves having the same frequency. The amplitude of the first driving waveform is greater than the amplitude of the second driving waveform with respect to the reference voltage. The maximum voltage to be applied with the first driving waveform is therefore greater than the maximum voltage to be applied with the second driving waveform. As the vibration intensity of the vibration elements **151** corresponds to the voltage of the applied driving waveform, the first vibration intensity driven with the first driving waveform in FIG. **7** is greater than the second vibration intensity driven with the second driving waveform in FIG. **8**.

[0102] Next, the vibration response process of the terminal **100** for performing the vibration response is described.

[0103] FIG. **9** is a flowchart showing control steps of the vibration response process to be performed by the controller **110** in the first embodiment.

[0104] The vibration response process starts when the operation display unit **140** displays the operation window on the display panel **141**.

[0105] When the vibration response process starts, the controller **110** determines whether or not a touch operation on the operation surface of the touchscreen **143** is detected on the basis of the detection signal from the touchscreen driver **144** (Step S**101**). When determining that a touch operation is not detected (Step S**101**: NO), the controller **110** repeats Step S**101**.

[0106] When determining that a touch operation is detected (Step S**101**: YES), the controller **110** performs the state determination process to determine whether or not the terminal **100** is in the placed state (Step S**102**).

[0107] FIG. **10** is a flowchart showing control steps of the state determination process by the controller **110**.

[0108] When the state determination process is called, the controller **110** determines whether or not the terminal **100** is placed on the cradle part **50** of the main body **200** (Step S**201**). Herein, the controller **110** determines that the terminal **100** is placed on the cradle part **50** when the terminal **100** is receiving power from the main body **200** via the connection terminal of the cradle part **50**. When determining that the terminal **100** is placed on the cradle part **50** (Step S**201**: YES), the controller **110** determines that the terminal **100** is in the placed state (Step S**202**).

[0109] When determining that the terminal **100** is not placed on the cradle part **50** (Step S**201**: NO), the controller **110** obtains an output signal from the inertial sensor **120** (Step S**203**). On the basis of the output signal, the controller **110** determines whether or not the terminal **100** is placed on a stationary place (i.e., placed at rest) (Step S**204**). Herein, the controller **110** determines that the terminal **100** is placed on a stationary place when the acceleration and/or the angular velocity detected by the inertial sensor **120** meet certain conditions. The conditions may be, for example, that the maximum value of the acceleration and/or the angular velocity during a certain period is smaller than a predetermined reference value. The reference value in the conditions is determined within the range of values smaller than the minimum value of the acceleration and/or the angular velocity that can be detected during a certain period when the terminal **100** is held and operated in the hand.

[0110] When determining that the terminal **100** is placed on a stationary place (Step S**204**: YES), the controller **110** determines that the terminal **100** is in the placed state (Step S**202**). When determining that the terminal **100** is not placed

on a stationary place (Step S**204**: NO), the controller **110** determines that the terminal **100** is in the held state (Step S**205**).

[0111] After Step S**202** or S**205**, the controller **110** ends the state determination process and returns to the vibration response process.

[0112] After ending the vibration response process in FIG. **9** (Step S**102**), when determining that the terminal **100** is in the placed state (Step S**103**: YES), the controller **110** sends a control signal to the vibration driver **152** to perform the vibration action at the first vibration intensity (Step S**104**). When determining that the terminal **100** is not in the placed state but in the held state (Step S**103**: NO), the controller **110** sends a control signal to the vibration driver **152** to perform the vibration action at the second vibration intensity that is weaker than the first vibration intensity (Step S**105**).

[0113] After Step S**104** or S**105**, the controller **110** ends the vibration response process.

[0114] In the above description, the controller **110** determines whether or not the terminal **100** is in the placed state by determining (i) whether or not the terminal **100** is placed on the cradle part **50** of the main body **200** and (ii) whether or not the terminal **100** is placed at rest on the basis of the output signal of the inertial sensor **120**. This is an example and not limitation.

[0115] For example, the controller **110** may determine whether or not the terminal **100** is in the placed state only by determining whether or not the terminal **100** is placed on the cradle part **50**. In the case, Steps S**203** and S**204** in FIG. **10** may be omitted.

[0116] As another example, the controller **110** may determine whether or not the terminal **100** is in the placed state only by determining whether or not the terminal **100** is placed at rest on the basis of the output signal of the inertial sensor **120**. In the case, the controller **110** may first perform Step S**203** in the state determination process in FIG. **10** without performing Step S**201**.

[0117] As described above, the terminal **100** in the first embodiment is a portable terminal for controlling the main body **200**. The terminal **100** includes: the operation display unit **140** with the touchscreen **143**; the operation-surface vibrator **150** that is configured to perform a vibration action of vibrating at least the operation surface **143***a* of the touchscreen **143**; and the controller **110**. The controller **110** as the state determination unit determines whether or not the terminal **100** is in a placed state of being placed on an object. The controller **110** as the vibration control unit causes the operation-surface vibrator **150** to perform the vibration action in response to a touch operation on the operation surface **143***a*. When the terminal **100** is in the placed state, the controller **110** causes the operation-surface vibrator **150** to perform the vibration action at first vibration intensity. When the terminal **100** is not in the placed state, the controller **110** causes the operation-surface vibrator **150** to perform the vibration action at second vibration intensity that is lower than the first vibration intensity.

[0118] According to this configuration, the terminal **100** in the placed state can perform the vibration response at appropriate intensity that can be felt with the finger on the operation surface **143***a*. When in the held state in which the user's finger and hand are in contact with the terminal **100**, the terminal **100** can perform the vibration response at the second vibration intensity weaker than the first vibration intensity. The terminal **100** thus can avoid annoying the user with too strong vibration and reduce power consumption by vibration.

[0119] Further, the terminal **100** includes the vibration absorber **171** that absorbs vibration propagating from the operation-surface vibrator **150** towards the object on which the terminal **100** is placed. According to this configuration, the terminal **100** placed on the cradle part **50** can prevent vibration of the operation-surface vibrator **150** from being transmitted to the main body **200**. The terminal **100** thus can avoid affecting the operation of the main body **200** with the vibration of the operation-surface vibrator **150**, while adjusting the vibration intensity of the operation-surface driver **150** such that the user can easily feel the vibration. More specifically, the terminal **100** can avoid decreasing the quality of image data formed by the image former **20** or generated by the scanner **30**, while increasing the vibration intensity in the placed state.

[0120] Further, the controller **110** determines that the terminal **100** is in the placed state when the terminal **100** is placed on the cradle part **50**. According to this configuration, the terminal **100** placed on the cradle part **50** can perform the vibration response at sufficient intensity so that the user feels the vibration with his/her finger touching the operation surface **143***a*.

[0121] Further, the controller **110** as the state determination unit determines that the terminal **100** is in the placed state in response to the terminal **100** receiving power from the main body **200**. According to this configuration, the controller **110** can easily and properly determine whether or not the terminal **100** is placed on the cradle part **50**.

[0122] Further, the terminal **100** includes the inertial sensor **120**, and the controller **110** as the state determination unit determines whether or not the terminal **100** is in the placed state based on an output of the inertial sensor **120**. According to this configuration, the terminal **100** placed on an object other than the cradle part **50** of the main body **200**, such as a table, can perform the vibration response the same way as the vibration response when placed on the cradle part **50**. When the terminal **100** is placed on an object other than the cradle part **50**, the user is not holding the terminal **100** but touching the terminal **10** only with his/her finger operating the operation surface **143***a*. The terminal **100** placed on the object other than the cradle part **50** performs the vibration action the same way as when placed on the cradle part **50**. The terminal **100** thus can perform the vibration response at sufficient intensity so that the user can feel the vibration with the finger touching the operation surface **143***a*.

[0123] Further, the program **113***a* in the first embodiment causes the controller **110** (computer) of the terminal **100** to function as a hardware processor that: determines whether or not the terminal **100** is in a placed state of being placed on an object; and causes the operation-surface vibrator **150** to perform the vibration action in response to a touch operation on the operation surface **143***a*, wherein when the terminal **100** is in the placed state, the hardware processor causes the operation-surface vibrator **150** to perform the vibration action at first vibration intensity, and when the terminal **100** is not in the placed state, the hardware processor causes the operation-surface vibrator **150** to perform the vibration action at second vibration intensity that is lower than the first vibration intensity.

[0124] According to such a program, the terminal **100** in the placed state can perform the vibration response at

sufficient intensity so that the user can feel the vibration with his/her finger on the operation surface **143***a*. Further, according to the program, the terminal **100** in the held state can avoid annoying the user with too strong vibration and can reduce power consumption by vibration.

Second Embodiment

[0125] Next, a second embodiment is described. The second embodiment is different from the first embodiment in that the terminal **100** predicts a touch operation and performs the vibration action according to the prediction. Hereinafter, aspects of the second embodiment that are different from the first embodiment are described.

[0126] When the terminal **100** is in the placed state, the terminal **100** has to start the vibration response before the user leaves his/her finger from the operation surface **143***a*, or the user can not feel the vibration. A touch time during which the user's finger is in contact with the operation surface **143***a* differs from user to user. For a user with a short touch time, the terminal **100** may not start the vibration response before the touch time ends.

[0127] In this second embodiment, the terminal **100** predicts a touch operation by detecting approach of the finger to the operation surface **143***a*. In response to predicting the touch operation, the terminal **100** starts the vibration action for the vibration response before the finger touches the operation surface **143***a*.

[0128] With the capacitance-type touchscreen **143**, capacitance coupling between the finger and the electrodes of the touchscreen **143** occurs when the finger is close to but not in touch with the operation surface **143***a* as well as when the finger is in contact with the operation surface **143***a*. The touchscreen **143** can therefore detect the approach of the finger to the operation surface **143***a* on the basis of changes in intensity of an electric field caused by capacitance coupling.

[0129] FIG. **11** is a figure to explain how the touchscreen **143** detects the approach of the finger.

[0130] In the top part of FIG. **11**, three cases with different distances d between the finger and the operation surface **143***a* are shown. In the left case, the finger is in touch with the operation surface **143***a*, where d=0. In the center case, the finger is separate from the operation surface **143***a* by the distance d**1**. In the right case, the finger is separate from the operation surface **143***a* by the distance d**2** that is greater than d**1**.

[0131] The graph in the bottom part of FIG. **11** shows the relation between the distance d and the intensity of the electric field E formed between the finger and the electrodes. As shown in the graph, the electric field E is strongest when the finger is in touch with the operation surface **143***a*, and becomes weaker as the distance d between the finger and the operation surface **143***a* is longer.

[0132] The approach of the finger to the operation surface **143***a* within the detection distance range dn can be detected by determining the threshold th of the electric field E to be detected (i.e., change in current that corresponds to electric field E). For example, when the threshold th of the electric field E is set to th**1** in FIG. **6**, the finger within the detection distance range d**1** to the operation surface **143***a* can be detected.

[0133] Hereinafter, a series of steps for predicting the touch of the finger and performing the vibration action at the timing when the finger approaches the operation surface **143** within the detection distance range dn is called the predictive response process.

[0134] FIG. **12** shows the first driving waveform in the predictive response process in the second embodiment. The first driving waveform shown in FIG. **12** is used when the terminal **100** is in the placed state.

[0135] In FIG. **12**, T**1** is the timing at which the finger is within the detection distance range dn to the operation surface **143***a*, and T**2** is the timing at which the finger touches the operation surface **143***a*. As shown in FIG. **12**, at the timing T**1** at which the finger is within the detection distance range dn, the first driving waveform is applied to start the vibration action for the vibration response, so that the vibration action has already been started at the timing T**2**. Accordingly, the terminal **100** can send a proper vibration response to the user even in in the placed state, in which only the user's finger touches the operation surface **143***a*. There may be a case where the terminal **100** cannot start vibration before the finger touches the operation surface **143***a* owing to a time lag between detecting the approach of the finger and starting the vibration. The terminal **100** can still start vibration earlier than in the case of starting vibration after detecting the touch of the finger. The vibration is therefore more likely to be sent while the finger is in contact with the operation surface **143***a*.

[0136] On the other hand, the terminal **100** in the held state does not perform the predictive response process but starts the vibration action for the vibration response in response to detecting the actual touch of the finger on the operation surface **143***a*.

[0137] This is firstly because the user can feel the vibration with the hand holding the lateral casing **173** of the terminal **100** even if the vibration does not start while the finger is in contact with the operation surface **143***a*.

[0138] Secondly, if the terminal **100** in the held state performs the predictive response process, the vibration response is started and transmitted to the user's hand holding the lateral casing **173** before the user's finger touches the operation surface **143***a*. Such a too early vibration response may be strange to the user.

[0139] Thirdly, when the prediction is wrong, the hand holding the lateral casing **173** may receive an inappropriate vibration response. There may be a case where the touch operation is not actually performed although the terminal **100** predicts a touch operation and starts vibration. In the case, the user receives the vibration response via the lateral casing **173** even though he/she has not touched the operation surface **143***a*. On the other hand, when the terminal **100** is in the placed state, the user does not receive such an inappropriate vibration response because the user is not holding the lateral casing **173** in his/her hand.

[0140] FIG. **13** shows the second driving waveform in the second embodiment. The second driving waveform in FIG. **13** is used when the terminal **100** is in the held state.

[0141] The terminal **100** in the held state does not perform the predictive response process nor perform vibration at the timing T**1** at which the finger is within the detection distance range dn. The terminal **100** starts applying the second driving waveform to start vibration action for the vibration response after detecting the touch of the finger at the timing T**2** and confirming the touched position at the timing T**3**. In a case where the finger leaves the operation surface **143***a* after the timing T**2** and before the timing T**3** at which the

vibration starts, the hand holding the lateral casing **173** receives vibration after the timing T**3**.

[0142] FIG. **14** is a flowchart showing control steps of the vibration response process to be performed by the controller **110** in the second embodiment.

[0143] The flowchart in FIG. **14** is different from the flowchart in FIG. **9** in that Steps S**106** to S**109** are added. Hereinafter, aspects different from the flowchart FIG. **9** are described.

[0144] After the state determination process in Step S**102**, when determining that the terminal **100** is in the placed state (Step S**103**: YES), the controller **110** starts the predictive response process (Step S**106**). The controller **110** determines whether or not the finger approaches the operation surface **143***a* within the detection distance range dn (Step S**107**). When determining that the finger is not within the detection distance range dn (Step S**107**: NO), the controller **110** repeats Step S**107**. When determining that the finger is within the detection distance range dn, namely predicting a touch operation (Step S**107**: YES), the controller **110** sends a control signal to the vibration driver **152** to perform the vibration action at the first vibration intensity (Step S**104**).

[0145] In Step S**103**, when determining that the terminal **100** is not in the placed state (i.e., the terminal **100** is in the held state) (Step S**103**: NO), the controller **110** performs the vibration response without performing the predictive response process. The controller **110** repeats determining whether or not a touch operation is detected until a touch operation on the operation surface **143***a* is detected (Step S**108**). When the touch operation is detected (Step S**108**: YES), the controller **110** performs the process of identifying the touched position until confirming the touched position (Step S**109**). When confirming the touched position (Step S**109**: YES), the controller **110** sends a control signal to the vibration driver **152** to perform the vibration action at the second vibration intensity weaker than the first vibration intensity (Step S**105**).

[0146] After Step S**104** or S**105**, the controller **110** ends the vibration response process.

[0147] In the above description, the first vibration intensity in the placed state is stronger than the second vibration intensity in the held state as an example. However, the vibration intensity may not be different between in the placed state and the held state if, as a result of the predictive response process, the user can certainly feel the vibration response of the terminal **100** in the placed state.

[0148] As described above, the terminal **100** in the second embodiment is a portable terminal for controlling the main body **200**. The terminal **100** includes: the operation display unit **140** with the touchscreen **143**; the operation-surface vibrator **150** that is configured to perform a vibration action of vibrating at least the operation surface **143***a* of the touchscreen **143**; and the controller **110**. The controller **110** as the vibration control unit controls the vibration action of the operation-surface vibrator **150**. The controller **10** as the state determination unit determines whether or not the terminal **100** is in a placed state of being placed on an object. The controller **110** as the touch-operation prediction unit makes a prediction on whether a touch operation is to be performed on the operation surface **143***a* by detecting the operation tool approaching the operation surface **143***a* within a certain distance. The controller **110** as the touch-operation detection unit detects the touch operation performed on the operation surface **143***a* with the operation tool. When the terminal **100** is in the placed state, the controller **110** as the vibration control unit causes the operation-surface vibrator **150** to start the vibration action in response to predicting the touch operation. When the terminal **100** is not in the placed state, the controller **110** as the vibration control unit causes the operation-surface vibrator **150** to start the vibration action in response to detecting the touch operation.

[0149] According to this configuration, the terminal **100** in the placed state can start the vibration response before the timing T**2** at which the finger touches the operation surface **143***a*. Accordingly, the terminal **100** in the placed state, in which only the finger touches the terminal **100**, can make sure to send the vibration response to the user. There may be a case where the terminal **100** cannot start vibration before the finger touches the operation surface **143***a* owing to a time lag between the detecting the approach of the finger and starting the vibration. The terminal **100** can still start vibration earlier than in the case of starting vibration after detecting the touch of the finger, so that the vibration is more likely to be sent to the finger while the finger is in contact with the operation surface **143***a*.

[0150] The terminal **100** in the held state does not perform the predictive response process but performs the vibration response when detecting the touch. The terminal **100** can therefore avoid sending an inappropriate vibration response to the hand holding the lateral casing **173** when the prediction is wrong. There may be a case where the touch operation is not actually performed although the terminal **100** predicts a touch operation and starts vibration. In the case, the terminal **100** can avoid sending the vibration response via the lateral casing **173** to the user who is not touching the operation surface **143***a*.

[0151] Further, the program **113***a* in the second embodiment causes the controller **110** (computer) of the terminal **100** to function as a hardware processor that: controls the vibration action of the operation-surface vibrator **150**; determines whether or not the terminal **100** is in a placed state of being placed on an object; makes a prediction on whether a touch operation is to be performed on the operation surface **143***a* by detecting the operation tool approaching the operation surface **143***a* within a certain distance; and detects the touch operation performed on the operation surface **143***a* with the operation tool. When the terminal **100** is in the placed state, the hardware processor causes the operation-surface vibrator **150** to start the vibration action in response to predicting the touch operation, and when the terminal **100** is not in the placed state, the hardware processor causes the operation-surface vibrator **150** to start the vibration action in response to detecting the touch operation.

[0152] According to this program, the terminal **100** in the placed state starts the vibration response before the timing T**2** at which the finger touches the operation surface **143***a*, so that the vibration response is certainly transmitted to the user. Further, according to this program, the terminal **100** in the held state can avoid sending an inappropriate vibration response to the user when the prediction is wrong.

Third Embodiment

[0153] Next, a third embodiment is described. The third embodiment is different from the first embodiment in that the terminal **100** further includes, in addition to the operation-surface vibrator **150**, a back-surface vibrator **160** that vibrates the back surface of the terminal **100**. Hereinafter,

aspects of the third embodiment that are different from the first embodiment are described. The third embodiment can be combined with the second embodiment.

[0154] FIG. **15** is a sectional view of a configuration of the terminal **100** in the third embodiment.

[0155] FIG. **16** is a block diagram showing main functional components of the terminal **100** in the third embodiment.

[0156] The terminal **100** in the third embodiment includes the back-surface vibrator **160** (second vibrator) in addition to the operation-surface vibrator **150**. The operation-surface vibrator **150** performs a first vibration action of vibrating the operation surface **143***a* of the touchscreen **143**. The back-surface vibrator **160** performs a second vibration action of vibrating the back surface of the terminal **100** opposite the operation surface **143***a* (i.e., vibrating the back surface **172***a* of the back casing **172**). The back-surface vibrator **160** includes a vibration element **161** placed near the back surface **172***a* of the back casing **172** (e.g., placed on the inner surface of the back casing **172**) and a vibration driver **162** that drives the vibration element **161**.

[0157] The vibration element **161** of the back-surface vibrator **160** directly vibrates the back surface **172***a*, so that a more perceivable vibration response is sent to the hand holding the terminal **100** than the vibration response sent from the vibration elements **151** of the operation-surface vibrator **150** to the lateral casing **173**. In the third embodiment, the terminal **100** in the held state performs the vibration action with the back-surface vibrator **160** to send the vibration response mainly to the hand that holds the back casing **172**. The terminal **100** may also perform the vibration action with the operation-surface vibrator **150** in addition to the vibration action with the back-surface vibrator **160**.

[0158] On the other hand, the terminal **100** in the placed state does not perform the vibration action with the back-surface vibrator **160** but performs the vibration action with the operation-surface vibrator **150**. The terminal **100** in the placed state thus sends the vibration action to the finger on the operation surface **143***a*. In the third embodiment, when the terminal **100** is placed on an object, the vibration absorber **171** between the operation display unit **140** and the back casing **172** absorbs vibration transmitted from the operation-surface vibrator **150** towards the object on which the terminal **100** is placed via the back casing **172**.

[0159] FIG. **17** is a flowchart showing control steps of the vibration response process to be performed by the controller **110** in the third embodiment.

[0160] The flowchart in FIG. **17** is different from the flowchart in FIG. **9** in that Steps S**104** and S**105** are replaced by Steps S**110** and S**111**, respectively. Hereinafter, aspects different from the flowchart in FIG. **9** are described.

[0161] After ending the vibration response process in Step S**102**, the controller **110** determines whether or not the terminal **100** is in the placed state (Step S**103**). When determining that the terminal **100** is in the placed state (Step S**103**: YES), the controller **110** sends a control signal to the vibration driver **152** of the operation-surface vibrator **150** to perform the vibration action (Step S**110**).

[0162] When determining that the terminal **100** is not in the placed state but in the held state (Step S**103**: NO), the controller **110** sends a control signal to the vibration driver **162** of the back-surface vibrator **160** to perform the vibration action (Step S**111**).

[0163] After Step S**110** or S**111**, the controller **110** ends the vibration response process.

[0164] As described above, the terminal **100** in the third embodiment is a portable terminal for controlling the main body **200**. The terminal **100** includes: the operation display unit **140** with the touchscreen **143**; the operation-surface vibrator **150** that is configured to perform a first vibration action of vibrating the operation surface **143***a* of the touchscreen **143**; the back-surface vibrator **160** that is configured to perform a second vibration action of vibrating the surface of the terminal **100** opposite the operation surface **143***a*; and the controller **110**. The controller **110** as the vibration control unit controls the first vibration action by the operation-surface vibrator **150** and the second vibration action by the back-surface vibrator **160**. The controller **110** as the state determination unit determines whether or not the terminal **100** is in a placed state of being placed on an object. When the terminal **100** is in the placed state, the controller **110** causes the operation-surface vibrator **150** to perform the first vibration action in response to a touch operation on the operation surface **143***a*. When the terminal **100** is not in the placed state, the controller **110** causes the back-surface vibrator **160** to perform the second vibration action in response to the touch operation on the operation surface **143***a*.

[0165] According to this configuration, when the terminal **100** is in the held state, the vibration element **161** of the back-surface vibrator **160** directly vibrates the back surface **172***a*. Such a vibration response can be more perceivable to the hand holding the terminal **100** than the vibration response with the operation-surface vibrator **150**, which is transmitted to the hand via the lateral casing **173**.

[0166] On the other hand, when the terminal **100** is in the placed state, the terminal **100** does not perform the vibration action with the back-surface vibrator **160** but performs the vibration action with the operation-surface vibrator **150**. Accordingly, the terminal **100** can avoid transmitting vibration to the main body **200** and affecting the operation of the main body **200**. This also can reduce power consumption by the vibration action.

[0167] Further, the program **113***a* in the third embodiment causes the controller **110** (computer) of the terminal **100** to function as a hardware processor that: controls the first vibration action by the operation-surface vibrator **150** and the second vibration action by the back-surface vibrator **160**; and determines whether or not the terminal **100** is in a placed state of being placed on an object, wherein when the terminal **100** is in the placed state, the hardware processor causes the operation-surface vibrator **150** to perform the first vibration action in response to a touch operation on the operation surface **143***a*, and when the terminal **100** is not in the placed state, the hardware processor causes the back-surface vibrator **160** to perform the second vibration action in response to the touch operation on the operation surface **143***a*.

[0168] According to the program, the terminal **100** in the held state can perform the vibration response that is more perceivable to the hand holding the terminal **100**. Further, the terminal **100** in the placed state can avoid transmitting vibration to the main body **200** and affecting the operation of the main body **200**. Further, power consumption by the vibration action can be reduced.

[0169] The above-described embodiments are not intended to limit the present invention and can be variously modified.

[0170] For example, whether or not the terminal **100** is placed on the cradle part **50** may not be determined by determining whether or not power is supplied to the terminal **100** by the main body **200**. For example, the state of the terminal **100** may be determined on the basis of the state of a physical button that is provided to terminal **100** and that is pressed when the terminal **100** is placed on the cradle part **50**.

[0171] As another example, the main body **200** may include a detection unit that detects whether or not the terminal **100** is placed on the cradle part **50** and that sends a detection signal to the terminal **100** when detecting that the terminal **100** is placed on the cradle part **50**. On the basis of the detection signal, the controller **110** of the terminal **100** can determine that the terminal **100** is placed on the cradle part **50**.

[0172] Further, although the cradle part **50** in the above description is electrically connectable to the terminal **100** via the connecting terminal of the supporter **52**, the cradle part **50** may be a placing surface that does not have a connecting terminal to the terminal **100** and that supplies power to the terminal **100** with contactless charging technology.

[0173] Further, when effects of the vibration of the back casing **172** on the main body **200** can be ignored (e.g., the cradle part **50** is provided with a damper), the back casing **172** may be integrated with the lateral casing **173** so that the vibration of the operation-surface vibrator **150** is transmitted to the back casing **172** and the back surface **172***a*.

[0174] Further, the touchscreen **143** may not be an electrostatic capacitance type but may be a resistance film type that detects the position touched by the operating tool according to connections between electrodes.

[0175] Although embodiments of the present invention have been described and illustrated in detail, the disclosed embodiments are made for purposes of illustration and example only and not limitation. The scope of the present invention encompasses the scope of the invention recited in the claims and the equivalent thereof.

What is claimed is:

1. A portable terminal for controlling an apparatus, comprising:

a display with a touchscreen;

a vibrator that is configured to perform a vibration action of vibrating at least an operation surface of the touchscreen; and

a hardware processor that

determines whether or not the terminal is in a placed state of being placed on an object and

causes the vibrator to perform the vibration action in response to a touch operation on the operation surface, wherein

when the terminal is in the placed state, the hardware processor causes the vibrator to perform the vibration action at first vibration intensity, and

when the terminal is not in the placed state, the hardware processor causes the vibrator to perform the vibration action at second vibration intensity that is lower than the first vibration intensity.

2. A portable terminal for controlling an apparatus, comprising:

a display with a touchscreen;

a vibrator that is configured to perform a vibration action of vibrating at least an operation surface of the touchscreen; and

a hardware processor that

controls the vibration action of the vibrator,

determines whether or not the terminal is in a placed state of being placed on an object,

makes a prediction on whether a touch operation is to be performed on the operation surface by detecting an operation tool approaching the operation surface within a certain distance, and

detects the touch operation performed on the operation surface with the operation tool, wherein

when the terminal is in the placed state, the hardware processor causes the vibrator to start the vibration action in response to predicting the touch operation, and

when the terminal is not in the placed state, the hardware processor causes the vibrator to start the vibration action in response to detecting the touch operation.

3. The terminal according to claim **1**, further comprising a vibration absorber that absorbs vibration propagating from the vibrator towards the object on which the terminal is placed.

4. The terminal according to claim **2**, further comprising a vibration absorber that absorbs vibration propagating from the vibrator towards the object on which the terminal is placed.

5. A portable terminal for controlling an apparatus, comprising:

a display with a touchscreen;

a first vibrator that is configured to perform a first vibration action of vibrating an operation surface of the touchscreen;

a second vibrator that is configured to perform a second vibration action of vibrating a surface of the terminal opposite the operation surface; and

a hardware processor that

controls the first vibration action by the first vibrator and the second vibration action by the second vibrator and

determines whether or not the terminal is in a placed state of being placed on an object, wherein

when the terminal is in the placed state, the hardware processor causes the first vibrator to perform the first vibration action in response to a touch operation on the operation surface, and

when the terminal is not in the placed state, the hardware processor causes the second vibrator to perform the second vibration action in response to the touch operation on the operation surface.

6. The terminal according to claim **5**, further comprising a vibration absorber that absorbs vibration propagating from the first vibrator towards the object on which the terminal is placed.

7. The terminal according to claim **1**, wherein the object is a cradle part of the apparatus.

8. The terminal according to claim **2**, wherein the object is a cradle part of the apparatus.

9. The terminal according to claim **5**, wherein the object is a cradle part of the apparatus.

10. The terminal according to claim **1**, wherein the hardware processor determines that the terminal is in the placed state in response to the terminal receiving power from the apparatus.

11. The terminal according to claim **2**, wherein the hardware processor determines that the terminal is in the placed state in response to the terminal receiving power from the apparatus.

12. The terminal according to claim **5**, wherein the hardware processor determines that the terminal is in the placed state in response to the terminal receiving power from the apparatus.

13. The terminal according to claim **1**, further comprising an inertial sensor, wherein the hardware processor determines whether or not the terminal is in the placed state based on an output of the inertial sensor.

14. The terminal according to claim **2**, further comprising an inertial sensor, wherein the hardware processor determines whether or not the terminal is in the placed state based on an output of the inertial sensor.

15. The terminal according to claim **5**, further comprising an inertial sensor, wherein the hardware processor determines whether or not the terminal is in the placed state based on an output of the inertial sensor.

16. A non-transitory computer-readable storage medium storing a program that causes a computer of a portable terminal, the terminal being for controlling an apparatus and including a display with a touchscreen and a vibrator that is configured to perform a vibration action of vibrating at least an operation surface of the touchscreen, to function as a hardware processor that:

determines whether or not the terminal is in a placed state of being placed on an object; and

causes the vibrator to perform the vibration action in response to a touch operation on the operation surface, wherein

when the terminal is in the placed state, the hardware processor causes the vibrator to perform the vibration action at first vibration intensity, and

when the terminal is not in the placed state, the hardware processor causes the vibrator to perform the vibration action at second vibration intensity that is lower than the first vibration intensity.

17. A non-transitory computer-readable storage medium storing a program that causes a computer of a portable terminal, the terminal being for controlling an apparatus and including a display with a touchscreen and a vibrator that is configured to perform a vibration action of vibrating at least an operation surface of the touchscreen, to function as a hardware processor that:

controls the vibration action of the vibrator;

determines whether or not the terminal is in a placed state of being placed on an object;

makes a prediction on whether a touch operation is to be performed on the operation surface by detecting an operation tool approaching the operation surface within a certain distance; and

detects the touch operation performed on the operation surface with the operation tool, wherein

when the terminal is in the placed state, the hardware processor causes the vibrator to start the vibration action in response to predicting the touch operation, and

when the terminal is not in the placed state, the hardware processor causes the vibrator to start the vibration action in response to detecting the touch operation.

18. A non-transitory computer-readable storage medium storing a program that causes a computer of a portable terminal, the terminal being for controlling an apparatus and including: a display with a touchscreen; a first vibrator that is configured to perform a first vibration action of vibrating an operation surface of the touchscreen; and a second vibrator that is configured to perform a second vibration action of vibrating a surface of the terminal opposite the operation surface, to function as a hardware processor that:

controls the first vibration action by the first vibrator and the second vibration action by the second vibrator; and

determines whether or not the terminal is in a placed state of being placed on an object, wherein

when the terminal is in the placed state, the hardware processor causes the first vibrator to perform the first vibration action in response to a touch operation on the operation surface, and

when the terminal is not in the placed state, the hardware processor causes the second vibrator to perform the second vibration action in response to the touch operation on the operation surface.

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