(54) Title: ELECTRONIC APPARATUS, VIBRATION GENERATOR, VIBRATORY INFORMING METHOD AND METHOD FOR CONTROLLING INFORMATION

(54) Title of the Invention: ELECTRONIC APPARATUS, VIBRATION GENERATOR, VIBRATORY INFORMING METHOD AND METHOD FOR CONTROLLING INFORMATION

(57) Abstract: An electronic apparatus generates a vibration by actuating a vibratory actuator upon detecting a fact that an operational input to a touch panel or an operating key is received. The electronic apparatus vibrates the touch panel and the operating key in the direction perpendicular to the surface thereof or vibrates the housing of the electronic apparatus. The vibratory actuator comprises a weight, a member for supporting the weight reciprocating in the air and coupled with a member of the electronic apparatus to be vibrated, e.g. the touch panel or the housing, or the base member of the vibratory actuator abutting on the member to be vibrated, and a mechanism for reciprocating the weight by applying a magnetic force or an electrostatic force thereto.

102...TOUCH PANEL
103...DISPLAY SECTION
111...KEY INPUT SECTION
112...MEMORY
114...DRIVE SIGNAL GENERATING CIRCUIT
115...VIBRATORY ACTUATOR
a...DRIVE SIGNAL
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For 2 character codes and other abbreviations, refer to "Guidance Notes for Codes and Abbreviations" included at the beginning of each PCT Gazette

(57) Abstract:

An electronic apparatus drives a vibration actuator when it is detected that an operation input to a touch panel or operation key has been received, and generates a vibration. The electronic apparatus causes vibration of the touch panel or operating key by this vibration in a direction perpendicular to the surface of the touch panel or operating key. Alternatively, the housing of the electronic apparatus is made to vibrate. Furthermore, the vibration actuator contains a weighted body, a supporting member that supports the weighted body in a reciprocally movable manner, and is connected to a vibrated member of the electronic apparatus such as the touch panel or housing, or the like, or to a base member of the vibration actuator that contacts with the vibrated member, and a mechanism that provides a magnetic force or an electrostatic force or the like to the weighted body in order to cause reciprocal movement.
Specification
Title of the Invention: ELECTRONIC APPARATUS, VIBRATION GENERATOR, VIBRATORY INFORMING METHOD AND METHOD FOR CONTROLLING INFORMATION

TECHNICAL FIELD
The present invention relates to a user interface for an electronic apparatus, and to a vibration generating mechanism.

BACKGROUND TECHNOLOGY
Various types of electronic apparatuses such as Personal Digital Assistants (PDA), personal computers, and Automatic Teller Machines (ATM) and the like have a user interface such as, for example, operating buttons, a keyboard, a touch panel, and the like. The user inputs characters through the user interface and inputs operations to the electronic apparatus such as selection of a process to execute, and the like.

Incidentally, mobile electronic apparatuses with a keyboard or operating buttons have poor pressing feel when a key or operating button is pressed because the keys and operating buttons have been made small, lightweight, and thin, in conjunction with the move to reduce the size, weight, and thickness of mobile electronic apparatuses. Therefore, the user must look at the display contents of the screen to confirm whether or not a pressing operation of a key or the operating button has been received by the mobile electronic apparatus.

Furthermore, the touch operation is performed on the touch panel using the fingertip or an accessory pen on electronic apparatuses provided with a touch panel, for example. At this time, if the manner of touching by the fingertip or pen on the touch panel is poor, or if the level of pressing is weak, the touch operation will be ineffective. Therefore, the user still must look at the display contents of the screen to confirm whether or not the touch operation on the touch panel has been received by the electronic apparatus.

Furthermore, there are electronic apparatuses that notify the user that an operation input has been received using a beep sound, but notification by these sounds are mostly ineffective in noisy areas such as when on the town, for example.

DISCLOSURE OF THE INVENTION
An object of the present invention is to provide an electronic apparatus that can easily confirm that an operation input has been received or a response of the electronic apparatus to an operation input, without the user looking at the screen, and also to provide a vibration generator notification method using vibration, and a method of controlling notification.

In order to achieve the aforementioned object, the present invention provides an electronic apparatus containing an operating part that receives an operation input, a vibration generator that provides vibration to a grasping part of the electronic apparatus, and vibration controlling means that generates vibration from the vibration generator when receipt of an operation input to the operating part is detected. Furthermore, the present invention provides a method for notifying by vibration in an electronic apparatus causing vibration of a grasping part of the electronic apparatus by causing generation of vibration from a vibration generator contained in the electronic apparatus, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input was received by vibrating a grasping part of the electronic apparatus.
Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; a vibration generator that provides vibration to the operating part; and vibration controlling means that generates vibration from the vibration generator when receipt of an operation input to the operating part is detected; the vibration generator comprising: a weighted body; a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the operating part, or a base member of the vibration generator that is in contact with the operating part; and motive force generating means that provides a motive force for causing reciprocal motion in the weighted body. Furthermore, the present invention provides a method of notifying by vibrating an electronic apparatus, comprising: driving a vibration generator contained in the electronic apparatus, and causing vibration of the operating part by causing reciprocal motion in a weighted body supported in air in a reciprocally movable manner by a supporting member that is connected to the operating part or a base member of the vibration generator that is in contact with the operating part.

With the present invention, the electronic apparatus notifies the operator that an operation input was received by vibrating an operating part.

Furthermore, the present invention provides an electronic apparatus containing an operating part that receives an operation input, a vibration generator that provides vibration to an operator, and vibration controlling means that generates vibration from the vibration generator when execution of a process that was instructed by the operation input to the operating part is detected as completed. Furthermore, the present invention provides a method for notifying by vibration in an electronic apparatus comprising: providing vibration to a user by causing generation of vibration from a vibration generator provided in the electronic apparatus when completion of execution of a process instructed by the operating input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that execution of the process instructed by the operating input is completed.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; a first vibration generator that provides vibration to the operating part; and a vibration generator that provides vibration to a grasping part of the electronic apparatus; and vibration controlling means that generates vibration from at least one of the first vibration generator and the second vibration generator as specified beforehand by the operator, when receipt of an operation input to the operating part is detected.

Furthermore, the present invention provides a method of notifying by vibration in an electronic apparatus, comprising: providing vibration to an operator by causing generation of vibration from at least one of a first vibration generator that provides vibration to the operating part and a second vibration generator that provides vibration to the grasping part of the electronic apparatus, as specified beforehand by the operator, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input was received by vibrating a region specified beforehand by the operator.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; a first vibration generator that provides vibration to the operating part; and a vibration generator that provides vibration to a grasping part of the electronic apparatus; detecting means that detects if the electronic apparatus is held by an operator; and vibration controlling means that selects at least one of the first vibration generator and the second vibration generator based on the detection results of the detecting means, and causes vibration of the selected vibration generator, when receipt of an operation input to
the operating part is detected. Furthermore, the present invention provides a method of notifying by vibrating an electronic apparatus, comprising selecting one or more of the first vibration generator that provides vibration to the operating part, provided in the electronic apparatus, and a second vibration generator that provides vibration to the grasping part of the electronic apparatus, based on detection results of a sensor that detects whether or not the electronic apparatus is being grasped by an operator, and provides vibration to the operator by causing generation of vibration from the selected vibration generator, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input was received, by vibrating different regions of the electronic apparatus, based on whether or not the electronic apparatus is being grasped by the operator.

Furthermore, the present invention provides an electronic apparatus, comprising: a display panel with a touch panel overlaid thereon; a vibration generator provided in the display panel; an elastic member configured using an elastic body, that supports the display panel in a manner that can vibrate by the vibration generated from the vibration generator; and vibration controlling means that causes generation of vibration from the vibration generator when receipt of a touch operation to the touch panel is detected; the vibration generator comprising: a weighted body; a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the display panel or a base member of the vibration generator that is in contact with the display panel; and motive force generating means that provides a motive force for causing reciprocal motion to the weighted body.

With the present invention, the electronic apparatus notifies the operator that a touch operation has been received by causing vibration of the touch panel and the display panel.

Furthermore, the present invention provides an electronic apparatus, comprising: a display panel with a touch panel overlaid thereon; a vibration generator that provides vibration to the display panel and supports the display panel; vibration controlling means that causes generation of vibration from the vibration generator when receipt of a touch operation to the touch panel is detected; the vibration generator comprising: a weighted body; a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the display panel or a base member of the vibration generator that is in contact with the display panel; and motive force generating means that provides a motive force for causing reciprocal motion to the weighted body.

With the present invention, the electronic apparatus notifies the operator that a touch operation has been received by causing vibration of the touch panel and the display panel.

Furthermore, the present invention provides an electronic apparatus, comprising: a display; a touch panel that covers the display surface of the display; a vibration generator provided between the display and the touch panel, that supports the touch panel on the display screen, and that provides vibration to the display panel; vibration controlling means that causes generation of vibration from the vibration generator when receipt of a touch operation to the touch panel is detected.

With the present invention, the electronic apparatus notifies the operator that a touch operation was received by vibrating an the touch panel.

Furthermore, the present invention provides an electronic apparatus, comprising: a display; a touch panel that covers the display surface of the display; a vibration generator that provides vibration to the touch panel and is installed on the touch panel; a vibration absorbing member provided between the display and the
touch panel, that absorbs the vibrational component that is transferred to the display, of the vibration generated by the vibration generator; and vibration controlling means that causes generation of vibration from the vibration generator when receipt of a touch operation to the touch panel is detected.

With the present invention, the electronic apparatus notifies the operator that a touch operation was received by vibrating only the touch panel on the display screen.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; a vibration generator provided such that at least a portion is exposed to the outside from the housing of the electronic apparatus, and that provides direct vibration to an operator; vibration controlling means that generates vibration from the vibration generator when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that a touch operation was received by providing a vibration to the operator directly from the vibration generator.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; a vibration generator that provides vibration to a portion of the housing of the electronic apparatus that is different from the operating part; and vibration controlling means that specifies the type of operation input, and causes generation of vibration from the vibration generator in a vibration form that corresponds to the type of operation input, when receipt of an operation input to the operating part is detected. Furthermore, the present invention provides a method for notifying by vibrating the electronic apparatus, comprising specifying the type of operation input, and causing generation of vibration of vibration from a vibration generator provided in the electronic apparatus, in a vibration form corresponding to the type of operation input, and causing vibration to a portion of the housing of the electronic apparatus that is different from the operating part, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input was received by vibrating a portion of the housing that is different than the operating part with a vibration form corresponding to the type of operating input.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; a vibration generator that provides vibration to a portion of the housing of the electronic apparatus that is different from the operating part; and changing means that changes a parameter value for controlling the electronic apparatus based on the operation input to the operating part; and vibration controlling means that causes generation of vibration from the vibration generator in a vibration form that corresponds to the parameter value that was changed by the changing means based on the operation input, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input that changes a parameter value was received by vibrating a portion of the housing that is different than the operating part with a vibration form corresponding to the changed parameter value.
corresponds to the type of operation input, when receipt of an operation input to the operating part is detected;

the vibration generator comprising: a weighted body; a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the operating part, or a base member of the vibration generator that is in contact with the operating part; and motive force generating means that provides a motive force for causing reciprocal motion in the weighted body.

Furthermore, the present invention provides a method of notifying by vibrating an electronic apparatus, comprising: specifying the type of operation input, driving a vibration generator contained in the electronic apparatus, and causing vibration of the operating part by causing reciprocal motion in a weighted body supported in air in a reciprocally movable manner by a supporting member that is connected to the operating part or a base member of the vibration generator that is in contact with the operating part.

With the present invention, the electronic apparatus notifies the operator that an operation input was received by vibrating the operating part with a vibration form corresponding to the type of operating input.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; a vibration generator that provides vibration to the operating part; and changing means that changes a parameter value for controlling the electronic apparatus based on the operation input to the operating part; and vibration controlling means that causes generation of vibration from the vibration generator in a vibration form that corresponds to the parameter value that was changed by the changing means based on the operation input, when receipt of an operation input to the operating part is detected, the vibration generator comprising: a weighted body; a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the operating part, or a base member of the vibration generator that is in contact with the operating part; and motive force generating means that provides a motive force for causing reciprocal motion in the weighted body.

With the present invention, the electronic apparatus notifies the operator that an operation input that changes a parameter value was received by vibrating the operating part with a vibration form corresponding to the changed parameter value.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input, and detects the level of pressing of the operation input; a vibration generator that provides vibration to the operator; and vibration controlling means that causes generation of vibration from the vibration generator in a vibration form that corresponds to the pressing level of the operation input that was detected by the operating part, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input that changes a parameter value was received by a vibration form corresponding to the changed parameter value.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input, and detects the level of pressing of the operation input; a vibration generator that provides vibration to the operator; and vibration controlling means that causes generation of vibration from the vibration generator in a vibration form that corresponds to the pressing level of the operation input that was detected by the operating part, when receipt of an operation input to the operating part is detected.
With the present invention, the electronic apparatus notifies the operator that an operation input was received by a vibration form corresponding to the pressing level of operating input.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; sound generating means that provides a notification sound to the operator; a vibration generator that provides vibration to the operator; and notification controlling means that notifies the operator that an operation input has been received using one or more of the sound generating means and the vibration generator, specified beforehand by the operator, when receipt of an operation input to the operating part is detected. Furthermore, the present invention provides a method for controlling notification in an electronic apparatus, comprising notifying the operator that an operation input has been received using one or more of the sound generating means and the vibration generator provided in the electronic apparatus, specified beforehand by the operator, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input was received by a vibration or sound, as specified beforehand by the operator.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; sound generating means that provides a notification sound to the operator; a vibration generator that provides vibration to the operator; and measuring means that measures the volume of sound around the electronic apparatus; and notification controlling means that selects one or more of the sound generating means and the vibration generator based on the measurement results of the measuring means, and notifies the operator that an operation input has been received using the selected means, when receipt of an operation input to the operating part is detected. Furthermore, the present invention provides a method of controlling notification in an electronic apparatus, comprising: selecting one or more of the sound generating means and the vibration generator that provides vibration to the operator, provided in the electronic apparatus, based on the measurement results of the measuring device that measures the noise volume around the electronic apparatus, and notifying the operator that an operation input has been received, using the selected means, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input was received by vibration or sound, depending on the volume of noise in the area around the electronic apparatus.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; sound generating means that provides a notification sound to the operator; a vibration generator that provides vibration to the operator; and receiving means that receives a signal specifying at least one of the sound generating means or the vibration generator from a base station that covers an area where the electronic apparatus exists; and notification controlling means that notifies the operator that an operation input has been received using one or more of the sound generating means and the vibration generator, specified by the signal received from the receiving means, when receipt of an operation input to the operating part is detected. Furthermore, the present invention provides a method of controlling notification in an electronic apparatus, comprising notifying the operator that an operation input has been received using one or more of the sound generating means that provides a notification sound to the operator, and a
vibration generator that provides vibration to the operator, specified by the signal received from a base station that covers the area where the electronic apparatus exists, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input was received by vibration or sound, depending on instructions from the base station that covers the area where the electronic apparatus exists.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; a vibration generator that can cause generation of noise at the same time as providing vibration to an operator; and drive controlling means that synthesizes a drive signal for causing generation of vibration and driving the vibration generator, and an audio signal for causing generation of a sound by driving the vibration generator, and applying the synthesized signals to the vibration generator, when causing generation of sound and vibration from the vibration generator, when receipt of an operation input to the operating part is detected. Furthermore, the present invention provides a method for notifying by vibration in an electronic apparatus, comprising: synthesizing a drive signal for causing generation of vibration and driving the vibration generator, and an audio signal for causing generation of a sound by driving the vibration generator using the synthesized signal, when causing generation of sound and vibration from the vibration generator provided in the electronic apparatus, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input was received by vibrating using the vibration generator, and generates a sound from the vibration generator based on the audio signal.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating part that receives an operation input; sound generating means that provides a notification sound to the operator; a vibration generator that provides vibration to the operator; and acquiring means that acquires positional information for the electronic apparatus; notification controlling means that selects one or more of the sound generating means and the vibration generator based on positional information acquired by the acquiring means, and notifies the operator that an operation input has been received using the selected means, when receipt of an operation input to the operating part is detected. Furthermore, the present invention provides a method of controlling notification in an electronic apparatus, comprising: selecting one or more of the sound generating means and the vibration generator that provides vibration to the operator, provided in the electronic apparatus, based on the positional information of the electronic apparatus, and notifying the operator that an operation input has been received, using the selected means, when receipt of an operation input to the operating part is detected.

With the present invention, the electronic apparatus notifies the operator that an operation input was received, by vibration or sound, depending on the current position of the electronic apparatus.

Furthermore, the present invention provides an electronic apparatus, comprising: an operating panel that receives a touch operation; a plurality of vibration generators that provide vibration to the operating panel; detecting means that detects the touch position on the operating panel; vibration controlling means that selects one or more of the plurality of vibration generators based on the touch position of the touch operation that was detected by the detecting means, and causes generation of vibration from the vibration generator that was selected, when receipt of a touch operation to the touch panel is detected. Furthermore, the present invention provides a method for notifying by
vibration in an electronic apparatus, comprising: detecting a touch position when receipt of a touch operation to the touch panel is detected, selecting one or more of the plurality of vibration generators provided in the electronic apparatus, based on the touch position, and providing vibration to the operator by causing generation of vibration from the vibration generator that was selected.

With the present invention, the electronic apparatus switches the vibration generator that is driven depending on the touch position, when notifying the operator that an operation input was received, by vibrating.

Furthermore, the present invention provides an electronic apparatus, comprising:

- an operating panel that receives a touch operation;
- a plurality of vibration generators that provide vibration to the operating panel;
- detecting means that detects the touch position on the operating panel;
- generating means that reproduces a drive signal that drives each of the plurality of vibration generators so as to amplify the amplitude of the vibration generated at the touch position of the touch operation that was detected by the detecting means, by mutual interference of the vibration waves generated from each of the plurality of vibration generators, when receipt of a touch operation to the touch panel is detected; and
- vibration controlling means that applies each of the drive signals reproduced by the generating means to the corresponding vibration generator, and reproduces the vibration from each of the vibration generators. Furthermore, the present invention provides a method of notifying by vibration in an electronic apparatus, comprising: detecting a touch position when receipt of a touch operation to the touch panel is detected, driving each of the vibration generators by generating a drive signal that is applied to each of the plurality of vibration generators so as to amplify the amplitude of the vibration generated at the touch position on the touch panel, by mutual interference of the vibration waves generated from each of the plurality of vibration generators, and providing vibration to the operator.

With the present invention, the electronic apparatus amplifies the amplitude of the vibration generated at the touch position on the operating panel, by mutual interference of the vibration waves generated from each vibration generator, when notifying the operator that an operation input was received, by causing generation of vibration from a plurality of vibration generators.

Furthermore, the present invention provides an electronic apparatus, comprising:

- an operating panel where a deformation layer that can deform by vibration is laminated;
- a plurality of vibration generators that provide vibration to the operating panel;
- detecting means that detects the touch position on the operating panel;
- generating means that reproduces a drive signal that drives each of the plurality of vibration generators so as to make the layer thickness of the deformation layer to be thicker or thinner compared to when not touched, at the touch position of the touch operation that was detected by the detecting means, by mutual interference of the vibration waves generated from each of the plurality of vibration generators, when receipt of a touch operation to the touch panel is detected; and
- vibration controlling means that applies each of the drive signals reproduced by the generating means to the corresponding vibration generator, and reproduces the vibration from each of the vibration generators. With the present invention, the electronic apparatus makes the layer thickness of the shape changing layer at the touch position on the operating panel thicker or thinner compared to the condition when untouched, by mutual interference of the vibration waves generated from each vibration generator, when notifying the operator that an operation input was received, by causing generation of vibration from a plurality of vibration generators.
Furthermore, the present invention provides a vibration generator, comprising a weighted body, a supporting member that supports the weighted body in air in a linear reciprocally movable manner, and that is connected to the vibration subjected body that is provided vibration by the vibration generator, or to the base member of the vibration generator that is connected to the vibration subjected body; motive force generating means that provides a motive force for causing reciprocal motion to the weighted body; and a resistance providing member that always contacts a side surface that runs parallel to the direction of reciprocal motion of the weighted body that performs linear reciprocal motion due to the motive force generated by the motive force generating means, and provides contact resistance to the weighted body.

With the present invention, the reciprocal movement of the weighted body can be quickly stopped by the contact resistance when generation of the motive force by the motive force generating means is stopped.

Furthermore, the present invention provides a vibration generator, comprising: a weighted body; a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to a vibration subjected member is provided vibration by the vibration generator or a base member of the vibration generator that is in contact with a vibration subjected member; and motive force generating means that provides a motive force for causing reciprocal motion to the weighted body; and braking means that stops the reciprocal motion of the weighted body by contacting with the weighted body, when generation of the motive force by the motive force generating means is stopped.

With the present invention, the reciprocal movement of the weighted body can be quickly stopped by the braking means, when generation of the motive force by the motive force generating means is stopped.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view illustrating an example of an appearance of a PDA according to the first embodiment of the present invention.

Fig. 2 is a block diagram illustrating an example of the hardware configuration of the PDA according to the same embodiment.

Fig. 3 is a cross section view schematically illustrating an example where a vibration actuator is provided in the main body case of a PDA according to the same embodiment.

Fig. 4 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator according to the same embodiment.

Fig. 5 is a flowchart for describing the operation of vibration control process 1 executed by a CPU in the PDA according to the same embodiment.

Fig. 6 is a block diagram illustrating an example of the hardware configuration of the PDA according to the second embodiment of the present invention.

Fig. 7 is a cross section view schematically illustrating an example where a vibrator is provided in the main body case of a PDA according to the same embodiment.

Fig. 8 is a perspective view illustrating an example of an appearance of a DC motor according to the same embodiment.

Fig. 9 is a diagram illustrating an example of the waveform of the drive voltage that is applied to the vibrator according to the same embodiment.

Fig. 10 is a diagram illustrating an example of the vibration generated on the surface of the touch panel according to the same embodiment.
Fig. 11 is a flowchart for describing the operation of vibration control process 2 executed by a CPU in the PDA according to the same embodiment.

Fig. 12 is a perspective view illustrating an example of an appearance of a PDA according to the third embodiment of the present invention.

Fig. 13 is a block diagram illustrating an example of the hardware configuration of the PDA according to the same embodiment.

Fig. 14 is a flowchart for describing the operation of vibration control process 3 executed by a CPU in the PDA according to the same embodiment.

Fig. 15 is a flowchart for describing the operation of vibration control process 4 executed by a CPU in the PDA according to the same embodiment.

Fig. 16 is a perspective view illustrating an example of the internal structure of a PDA according to the fourth embodiment of the present invention.

Fig. 17 is a block diagram illustrating an example of the hardware configuration of the PDA according to the same embodiment.

Fig. 18 is a flowchart for describing the operation of vibration control process 5 executed by a CPU in the PDA according to the same embodiment.

Fig. 19 is a cross-section view illustrating an example of the internal structure of a PDA according to a first alternate example of the same embodiment.

Fig. 20 is a diagram illustrating an example of another placement of the elastic member according to the same embodiment.

Fig. 21 is a diagram illustrating an example of another placement of the elastic member according to the same embodiment.

Fig. 22 is a diagram illustrating an example of another placement of the elastic member according to the same embodiment.

Fig. 23 is a diagram illustrating an example of the internal structure of a PDA according to a second alternate example of the same embodiment.

Fig. 24 is a diagram illustrating an example of the internal structure of a PDA according to a third alternate example of the same embodiment.

Fig. 25 is a cross-section view for describing the internal structure of an ATM according to the fifth embodiment of the present invention.

Fig. 26 is a cross-section view illustrating an alternate example of the placement position of the vibration actuator according to the same embodiment.

Fig. 27 is a cross-section view illustrating an example of the internal structure of an ATM according to a first alternate example of the same embodiment.

Fig. 28 is a diagram illustrating an example of the internal structure of an ATM according to a second alternate example of the same embodiment.

Fig. 29 is a diagram illustrating an example of the internal structure of an ATM according to a third alternate example of the same embodiment.

Fig. 30 is a diagram illustrating an example of the internal structure of an ATM according to a fourth alternate example of the same embodiment.

Fig. 31 is a diagram illustrating an example of the internal structure of an ATM according to a fifth alternate example of the same embodiment.

Fig. 32 is a diagram illustrating an example of the screen display of a PDA according to the first example of the sixth embodiment of the present invention.

Fig. 33 is a diagram illustrating an example of a waveform data table that is stored in the memory in a PDA according to a first example of the same embodiment.

Fig. 34 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator in the PDA according to the first example of the same embodiment.
Fig. 35 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator in the PDA according to the first example of the same embodiment.

Fig. 36 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator in the PDA according to the first example of the same embodiment.

Fig. 37 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator in the PDA according to the first example of the same embodiment.

Fig. 38 is a diagram illustrating an example of the screen display of a PDA according to the second example of the same embodiment.

Fig. 39 is a diagram illustrating an example of the screen display of a PDA according to the second example of the same embodiment.

Fig. 40 is a diagram illustrating an example of a waveform data table that is stored in the memory in a PDA according to a second example of the same embodiment.

Fig. 41 is a diagram illustrating an example of the screen display of a PDA according to the third example of the same embodiment.

Fig. 42 is a diagram illustrating an example of a waveform data table that is stored in the memory in a PDA according to a third example of the same embodiment.

Fig. 43 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator in the PDA according to the third example of the same embodiment.

Fig. 44 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator in the PDA according to the third example of the same embodiment.

Fig. 45 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator in the PDA according to the third example of the same embodiment.

Fig. 46 is a diagram illustrating an example of a waveform data table that is stored in the memory in a PDA according to the seventh embodiment of the present invention.

Fig. 47 is a block diagram illustrating an example of the hardware configuration of the PDA according to the eighth embodiment of the present invention.

Fig. 48 is a flowchart for describing the operation of notification control process 1 executed by a CPU in the PDA according to the same embodiment.

Fig. 49 is a diagram illustrating an example of the waveform of the drive signal for vibration that is applied to the vibration actuator in the PDA according to the same embodiment.

Fig. 50 is a diagram illustrating an example of the waveform of the drive signal for a beep sound that is applied to the vibration actuator in the PDA according to the same embodiment.

Fig. 51 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator when simultaneously providing notification by vibration and a beep sound, in the PDA according to the same embodiment.

Fig. 52 is a block diagram illustrating an example of the hardware configuration of the PDA according to the ninth embodiment of the present invention.

Fig. 53 is a flowchart for describing the operation of a beacon receiving process executed by a CPU in the PDA according to the same embodiment.

Fig. 54 is a diagram illustrating an example of a notification mode determining table that is stored in the memory in a PDA according to the tenth embodiment of the present invention.
Fig. 55 is a diagram for describing an ATM according to the 11th embodiment of the present invention.

Fig. 56 is a block diagram illustrating an example of the hardware configuration of the ATM according to the same embodiment.

Fig. 57 is a part of a flowchart for describing the operation of vibration control process 1 executed by a CPU in the ATM according to the same embodiment.

Fig. 58 is a part of a flowchart for describing the operation of vibration control process 1 executed by a CPU in the ATM according to the same embodiment.

Fig. 59 is a cross-section view for describing the touch panel of the ATM according to an alternate example of the same embodiment.

Fig. 60 is a cross-section view for describing the touch panel of the ATM according to an alternate example of the same embodiment.

Fig. 61 is a diagram for describing an ATM according to the 12th embodiment of the present invention.

Fig. 62 is a diagram illustrating an example of a drive target determining table that is stored in the memory in the ATM according to the same embodiment.

Fig. 63 is a flowchart for describing the operation of vibration control process 7 executed by a CPU in the ATM according to the same embodiment.

Fig. 64 is a cross-section view illustrating an example of the internal structure of the vibration actuator according to the first example of the 13th embodiment of the present invention.

Fig. 65 is a plan view illustrating a placement example of the braking member in the vibration actuator according to the first example of the same embodiment.

Fig. 66 is a plan view illustrating another placement example of the braking member in the vibration actuator according to the first example of the same embodiment.

Fig. 67 is a plan view illustrating yet another placement example of the braking member in the vibration actuator according to the first example of the same embodiment.

Fig. 68 is a diagram illustrating an example of the waveform of the drive signal that is applied to the coil of the vibration actuator according to the first example of the same embodiment.

Fig. 69 is a diagram for describing the reciprocal motion of the movable weight of a vibration actuator without a brake mechanism.

Fig. 70 is a diagram for describing the reciprocal motion of the movable weight of a vibration actuator according to the first example of the same embodiment.

Fig. 71 is a cross-section view illustrating an example of the internal structure of the vibration actuator according to the second example of the same embodiment.

Fig. 72 is a diagram illustrating an example of the configuration of a circuit for applying a drive signal to the coil of the vibration actuator and the braking coil according to the second example of the same embodiment.

Fig. 73 is a diagram illustrating an example of the waveform of the drive signal that is applied to the coil of the vibration actuator according to the second example of the same embodiment.

Fig. 74 is a diagram illustrating an example of the waveform of the drive signal that is applied to the braking coil of the vibration actuator according to the second example of the same embodiment.

Fig. 75 is a cross-section view illustrating an example of the internal structure of the vibration actuator according to the third example of the same embodiment.

Fig. 76 is a diagram illustrating an example of the configuration of a circuit for applying a drive signal to the coil of the vibration actuator according to the third example of the same embodiment.
Fig. 77 is a diagram illustrating an example of the waveform of the CTRL signal that is supplied to the switching circuit according to the third example of the same embodiment.

Fig. 78 is a diagram illustrating an example of the operating panel according to the third alternate example of the present invention.

Fig. 79 is a diagram illustrating an example of a dial type switch according to the same alternate example.

Fig. 80 is a diagram illustrating an example of a "+" key and a "-" key according to the same alternate example.

Fig. 81 is a perspective view illustrating an example of the appearance of a remote controller for the electronic apparatus according to the same alternate example.

Fig. 82 is a diagram for describing an electrostatic type vibration actuator according to the fifth alternate example of the present invention.

Fig. 83 is a diagram for describing another electrostatic type vibration actuator according to the fifth alternate example of the present invention.

Fig. 84 is a cross-section view illustrating an example of the internal structure of the vibration actuator according to the sixth alternate example of the present invention.

Fig. 85 is a perspective view illustrating an example of an appearance of the ATM according to the eighth alternate example of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the present invention are described below. These embodiments illustrate one form of the present invention, and do not restrict the present invention, and can be arbitrarily changed within the scope of the present invention.

[A: First embodiment]
[A-1: Configuration of the first embodiment]

Fig. 1 is a perspective view illustrating an example of an appearance of a PDA 10 according to the first embodiment of the present invention. In this diagram, a transparent touch panel 102 is overlaid on a display screen of a liquid crystal display panel 103a that faces an opening part of the main body case 101. A user inputs operating commands to the PDA 10 by touching the touch panel 102 with a fingertip. Note, the touch operation on the touch panel 102 may also have a form where an operation tool such as a pen or the like is used. Furthermore, press down operating keys 104a, 104b, 104c four including operating commands to the PDA 10 such as a main power on/off operation or the like are provided on an upper surface of the main body case 101.

Next, Fig. 2 is a block diagram illustrating an example of the hardware configuration of the PDA illustrated in Fig. 2. As illustrated in this diagram, the PDA 10 has a touch panel 102, display part 103, key input part 111, memory 112, CPU (Central Processing Unit) 113, drive signal generating circuit 114, and a vibration actuator 115. The touch panel 102 outputs a signal indicating the touch position on the touch panel 102 based on the touch operation (hereinafter referred to as the touch signal) to the CPU 113. Note, the touch operation on the touch panel 102 may also have a form where an operation tool such as a pen or the like is used. Furthermore, press down operating keys 104a, 104b, 104c four including operating commands to the PDA 10 such as a main power on/off operation or the like are provided on an upper surface of the main body case 101.

The CPU 113 controls each part of the devices that are connected through a bus 116 by executing a program that is stored in the memory 112. The CPU
executes the vibration control process 1 (refer to Fig. 5), and drives the vibration actuator 115 by a drive signal generating circuit 114 to cause the touch panel 102 and the operating keys 104a to 104c to vibrate, when an operation input is detected from the touch panel 102 or the operating keys 104a to 104c.

The drive signal generating circuit 114 generates a drive signal for driving the vibration actuator 115 based on the waveform data supplied from the CPU 113. Furthermore, the drive signal generating circuit 114 applies a drive signal to the vibration actuator 115 based on instructions from the CPU 113.

The vibration actuator 115 uses a permanent magnet as the movable weight (weighted body), and is a so-called permanent magnet movable type linear oscillatory actuator that generates vibration by causing the movable weight to linearly reciprocally move by electromagnetic force. The vibration actuator 115 is driven by the drive signal applied from the drive signal generating circuit 114, and generates vibration.

Fig. 3 is a cross section view schematically illustrating an example of a condition where a vibration actuator 115 is provided in the main body case 101 of the PDA 10. As illustrated in this diagram, the upper surface of the case 115a of the vibration actuator 115 is in contact with the liquid crystal display panel 103a and the operating keys 104a to 104c. Furthermore, a cylindrical coil 121 attached to the upper surface of the case 115a, a cylindrical movable weight 122 formed from a permanent magnet with a ring shaped void where the coil 121 is stored, and a spring 123 that supports the movable weight 122 are provided inside of the case 115a of the vibration actuator 115.

Note, the case 115a of the vibration actuator 115 is sealed, and functions as a magnetic shield. In order to provide this function of a magnetic shield to the case 115a in this manner, the case 115a is formed from a conductive substance that is grounded or that is equipotential, or the case 115a is formed from a magnetic body with high magnetic permeability.

The movable weight 122 is supported in the space formed inside the case 115a of the vibration actuator 115 by a spring 123 in a condition that can reciprocally move linearly in the vertical direction of the figure. As illustrated in Fig. 3, one end of the spring 123 is connected to the case 115a (base member) that contacts with the liquid crystal display panel 103a and the operating keys 104a to 104c, and the other end is connected to the movable weight 122. Note, a configuration where a plurality of springs 123 are provided is also acceptable. Furthermore, a supporting member configured using an elastic body such as string shaped rubber or the like may also be used in place of the spring 123.

The movable weight 122 reciprocally moves linearly in the vertical direction of the figure by the magnetic force generated from the coil 121 when an alternating current (drive signal) is applied to the coil 121. Vibration acceleration is generated in a portion of the case 115a that is connected to the spring 123 as a reactive force to the reciprocal movement of the movable weight 122. Note, in addition to the reactive force of the reciprocal motion, a vibration component that is transferred through the spring 123 from the movable weight 122 is also applied, in conjunction with the reciprocal movement of the movable weight 122 to the portion of the case 115a that is connected to the spring 123, but the basic principle of generating vibration in the vibration actuator 115 uses the vibration acceleration generated as the reactive force of the reciprocal movement of the movable weight 122.

The vibration is transferred by the vibration acceleration to the liquid crystal display panel 103a and the operating keys 104a to 104c. The direction of vibration is the direction perpendicular to the surface of the touch panel 102, and matches the direction that the user presses the touch panel 102 and the operating keys 104a to 104c, and in the
opposite direction thereof. Therefore, the touch panel 102 and the operating keys 104a to 104c vibrate in the direction perpendicular to the surface of the touch panel 102, and the vibration is transferred to the fingertip of the user that is performing the operation input.

Incidentally, the vibration actuator 115 illustrated in Fig. 3 is sealed by a case 115a that has a magnetic shielding effect, but the case 115a is not necessarily sealed. Furthermore, the spring 123 that supports the movable weight 112 may be directly connected to the back surface of the liquid crystal display panel 103 rather than the case 115a.

Incidentally, using a vibration actuator 115 in a single package has the following advantages. In other words, if a vibration actuator that is not in a single package is used, the members of the vibration actuator must be installed separately to both the back surface of the liquid crystal display panel that is overlaid on the touch panel, and on the main body device of the electronic apparatus that supports the liquid crystal display panel. For example, a permanent magnet must be installed on the back surface of the liquid crystal display panel, and a coil must be installed at a position opposite to the permanent magnet on the main body device side of the electronic apparatus.

In this case, if the mounting precision of the separately installed members is poor, or if the mounting precision of the members deteriorate by changing over time, this will immediately cause surfacing as a vibration defect of the touch panel, and causing the touch panel to vibrate with stable precision will be difficult. Furthermore, the number of components will increase, and the cost of the final product will increase because the steps of the assembly operation of the electronic apparatus such as aligning the permanent magnet and the coil will be complex.

Furthermore, during separate installation, either the main body device and the housing of the electronic apparatus that supports the liquid crystal display panel must be firmly retained, or the mass of the supporting body must be sufficiently high with regard to the liquid crystal display panel, in order to efficiently vibrate the touch panel. Therefore, separate installation of the vibration actuator is not suitable for lightweight electronic apparatuses and mobile electronic apparatuses.

In contrast, if a vibration actuator 115 in a single package is used, the movable weight 122 (permanent magnet) and the coil 121 will be stored in the case 115a beforehand, so the mounting precision of the permanent magnet and the coil will be favorable, and there will be almost no deterioration. Furthermore, the installation precision of the permanent magnet and the coil will not easily deteriorate by changing over time, as compared to the case of separate installation. Therefore, the touch panel 102 can be made to vibrate with stable precision. Furthermore, the process of assembling the electronic apparatus can be simplified because the vibration actuator 115 that is in a single package is simply attached to the member to be vibrated, such as the back surface of the liquid crystal display panel 103a.

Furthermore, the vibration actuator 115 provides the vibration generated as a reactive force to the reciprocal movement by causing the movable weight 122 that is supported in the air to reciprocally move, to the liquid crystal display panel 103a that is connected to the movable weight 122. Therefore, if the supporting body such as the main body device of the PDA 10 and the main body case 101 or the like is not securely fastened, or if the mass of the supporting body is not sufficiently large with regard to the liquid crystal display panel 103a, the vibration actuator 115 can provide sufficiently large vibration to the liquid crystal display panel 103a or the like. This is particularly favorable when using a lightweight electronic apparatus or a mobile electronic apparatus.

Incidentally, when an audio signal in the audible region is applied to the coil 121 of the vibration actuator 115, the case 115a of the vibration actuator 115 and the
main body case 101 of the PDA 10 where the vibration actuator is installed will vibrate, and a sound that corresponds to the audio signal can be generated. In other words, the vibration actuator 115 can also be used as a sound generating source. In this case, a configuration is preferable where the volume of sound generated by the vibration actuator 115 is amplified using the liquid crystal display panel 103a and the main body case 101 and the like that transfer the vibration generated from the vibration actuator 115 as an acoustic loudspeaker mechanism. In this manner, the function of both a vibration generator and a sound generating source can be achieved, and thus the installation space of the components can be greatly conserved in small electronic apparatuses such as mobile phones, pagers and the like. Incidentally, if the vibration actuator 115 is made to function as a sound generating source, a configuration is also acceptable where an acoustic loudspeaker mechanism such as a cone paper or horn or the like is provided on the inside or outside of the vibration actuator 115.

Next, Fig. 4 is a diagram illustrating an example of the waveform of the drive signal that is applied to the vibration actuator 115. In this figure, the frequency $f_0$ of the drive signal applied to the vibration actuator 115 and the coil 121 matches the intrinsic vibration frequency $f_1$ of the main body case 101 of the PDA 10 or the intrinsic frequency $f_2$ of the vibration actuator 115 itself. When a drive signal with this frequency $f_0$ is applied to the coil 121, the main body case 101 of the PDA 10 or the vibration actuator 115 will resonate, and therefore a larger vibration can be provided to the user by low driving power. In other words, the power consumption of the PDA 10 can be conserved. This frequency data and amplitude data are stored in the memory 112 as waveform data of the drive signal.

Incidentally, the frequency $f_0$ of the drive signal can be set such that an integer multiple of this frequency $f_0$ matches the intrinsic frequency $f_1$ or the intrinsic frequency $f_2$. Even with this frequency $f_0$, the main body case 101 of the PDA 10 or the vibration actuator 115 will resonate. Furthermore, the waveform of the drive signal is not restricted to the SIN waves illustrated in Fig. 4, and naturally the waves may be square waves, trapezoidal waves, triangular waves, and the like.

[A-2: Function of the first embodiment]

Fig. 5 is a flowchart for describing the operation of vibration control process 1 executed by the CPU 113 in the PDA 10 according to the same embodiment. The vibration controlling process 1 is executed by the CPU 113 every predetermined period of time, in the time period that operation input is allowed to the touch panel 102 and the operating keys 104a to 104c.

As illustrated in the figure, first, the CPU 113 determines whether or not a touch signal from the touch panel 102 has been input, and whether or not a key operation signal from the key input part 111 has been input (step S101). If the CPU 113 determines that neither a touch signal nor a key operation signal has been input, the vibration control process 1 will be terminated. On the other hand, if the CPU 113 determines that one or more of the touch signal and the key operation signal has been input, first, the waveform data of the drive signal to be applied to the vibration actuator 115 is read from the memory 112 (step S102). Incidentally, even if the CPU 113 determines that a touch signal has been input from the touch panel 102 in step S101, the process of step S102 will not be performed and the vibration control process 1 will be terminated if the touch position on the touch panel 102 based on this signal is outside of the display region of a touch button that is displayed on the display screen, for example.

Next, the CPU 113 output the waveform data that was read from the memory 112 to the drive signal generating circuit 114. Furthermore, simultaneously, the
CPU 113 will instruct the drive signal generating circuit 114 to generate a drive signal (step S103). The drive signal generating circuit 114 generates a drive signal using the waveform data provided from the CPU 113 from the process of step S103.

Next, the CPU 113 resets the counter value for measuring the application time of the drive signal (step S104). Furthermore, this CPU 113 instructs the drive signal generating circuit 114 to start applying the drive signal (step S105). Furthermore, simultaneously, the CPU 113 will start measuring the application time (step S106). The drive signal generating circuit 114 is instructed to start application by the CPU 113, and applies a drive signal to the vibration actuator 115 for the period of time until instructed to stop applying by the CPU 113. Therefore, the vibration actuator 115 drives, and the touch panel 102 and the operating keys 104a to 104c vibrate in the direction perpendicular to the surface of the touch panel 102.

Furthermore, the CPU 113 increments the count value for the application start timing based on the timing start of the application time (step S107). Furthermore, the CPU 113 determines whether or not the count value has reached a count value that corresponds to the specified time that was preset (step S108). For example, in the present embodiment, the specified time is set to 0.5 seconds.

If the application time is less than the specified time, the CPU 113 returns to step S107 and increments the application time. Furthermore, if the CPU 113 determines that the application time exceeds the specified time, or in other words if the application time has reached 0.5 seconds, the CPU instructs the drive signal generating circuit 114 to stop application of the drive signal (step S109). Subsequently, the CPU 113 terminates the vibration control process 1. The drive signal generating circuit 114 stops application of the drive signal to the vibration actuator 115 when the CPU 113 instructs to stop application.

With the embodiment as described above, when the CPU detects an operation input to the touch panel 102 and the operating keys 104a to 104c, the vibration actuator 115 is driven, and the touch panel 102 or the operating keys 104a to 104c are made to vibrate. Therefore, the PDA 10 can notify the user by vibration that an operation input has been received. As a result, the user can confirm whether or not an operation input to the touch panel 102 or the operating keys 104a to 104c has been received by the PDA 10 without looking at the screen display. Furthermore, a linear vibration actuator is used as the vibration actuator 115, so the directional precision of the vibration generated by the vibration actuator 115 will be high. Therefore, when a touch operation is performed on the touch panel 102, or when a press down operation is performed on the thin operating keys 104a to 104c, the user can be provided with a pressing feel of the touch button or the operating keys by vibration stimulation, by incorporating into the PDA 10 a vibration actuator 115 such that the direction of vibration is perpendicular to the surface of the touch panel 102 or to the press down direction of the operating keys 104a to 104c.

Furthermore, this vibration actuator 115 can also be used as a sound generating source, by applying an audio signal in the audible region to the coil 121 of the vibration actuator 115.

Furthermore, if the vibration time is a short period of time such as 0.5 seconds or the like, for example, when the touch panel 102 or the operating keys 104a to 104c are operated, an operation feel similar to a so-called click feel can be provided to the user by the vibration stimulation. Herein, the click feel is an operation feel generated when performing an operation where a mouse is operated to select an icon or a button that is displayed on a screen of a display, for example and then the mouse button is pressed and released. The vibration time is preferably a maximum of 1 second or less, in order to provide this type of click feel. Furthermore, if the vibration time is a short...
period of time as described above, the drive power of the vibration actuator 115 is reduced, and the power consumed by the PDA 10 can be conserved.

Furthermore, the vibration actuator 115 stores a coil 121 and a movable weight 122 in a sealed case 115a as magnetic shielding. Therefore, the vibration actuator 115 is not affected by magnetic forces from peripheral components of the PDA 10 that are installed. Furthermore, the vibration actuator 115 does not affect other peripheral components by the magnetic force generated from the coil 121.

It is important that the vibration actuator 15 not be affected by the magnetic force from other peripheral components, from the perspective of maintaining constant directional precision of the reciprocal motion of the movable weight 122, or in other words of the vibration generated from the vibration actuator 115. This is because if the direction of vibration generated by the vibration actuator 115 is shifted due to the influence of a magnetic force from peripheral components, the pressing feel of the touch buttons and the operating keys cannot be provided to the user by vibration stimulation.

Furthermore, it is important from the perspective of preventing malfunction of peripheral components that the vibration actuator 115 does not have a magnetic influence on the peripheral components. With the present embodiment, the case was described where a liquid crystal display panel 103a is used. However, if a CRT (cathode ray tube) is used in place of the liquid crystal display panel 103a, there is a possibility that discoloration and warping will occur in the content displayed on the CRT because of the magnetic effect generated by the vibration actuator if a vibration actuator that does not have magnetic shielding effects is provided in proximity to the CRT in order to vibrate the touch panel 102.

Incidentally, with the present embodiment, a configuration where an operating part such as a touch panel 102 or operating keys 104a to 104c are vibrated, or in other words the case where vibration is provided to the fingertip of the user that is performing the operation input, was described. However, a configuration where the main body case 101 of the PDA 10 is vibrated, or in other words, where vibration is provided to the hand of the user that is grasping the PDA 10 rather than the fingertips that perform the operation input, is also acceptable.

[B: Second embodiment]

With this embodiment, the case where a vibrator that uses a DC motor is used as the vibration generator is described. Incidentally, with this embodiment, parts that are common with the first embodiment are assigned the same codes. Furthermore, a description of parts that are common with the first embodiment is omitted.

[B-1: Configuration of the second embodiment]

Fig. 6 is a block diagram illustrating an example of the hardware configuration of a PDA 20 according to the this embodiment. As illustrated in this figure, the PDA 20 has a touch panel 102, display part 103, key input part 111, memory 112, CPU (Central Processing Unit) 113, drive signal generating circuit 211, a vibrator 212, and an encoder 213.

Furthermore, the memory 112 stores waveform data of the drive voltage for driving the vibrator 212. The CPU executes the vibration control process 2 (refer to Fig. 11), and drives the vibrator 212 by a drive signal generating circuit 211 to cause the touch panel 102 and the operating keys 104a to 104c to vibrate, when an operation input is detected from the touch panel 102 or the operating keys 104a to 104c. Furthermore, the CPU 113 selects the timing to stop applying the drive signal to the vibrator 212, based on the rotational angle information provided from the encoder 213.
The drive signal generating circuit 211 generates a drive signal for driving the vibrator 212 based on the waveform data supplied from the CPU 113. Furthermore, the drive signal generating circuit 211 applies a drive signal to the vibrator 212 based on instructions from the CPU 113. Furthermore, the vibrator 212 is a DC motor with an eccentric weight attached to the rotating shaft. The vibrator 212 is driven by the drive signal applied from the drive signal generating circuit 211, and generates vibration.

Fig. 7 is a cross section view schematically illustrating an example of a condition where a vibrator 212 is provided in the main body case 101 of the PDA 20. Furthermore, Fig. 8 is a perspective view illustrating an example of an appearance of the vibrator 212. As illustrated in Fig. 7, the vibrator 212 that is stored in a case 212a is installed on a lower surface of the liquid crystal display panel 103a. This vibrator 212 is attached to the inside of the case 212a by a supporting member omitted from the figures. Furthermore, as illustrated in Fig. 7 and Fig. 8, the vibrator 212 is configured from a DC motor 223 where an eccentric weight 222 is attached to the tip end of a rotating shaft 221.

When a drive voltage (drive signal) is applied to the DC motor 223, the eccentric weight 222 attached to the rotating shaft 221 will rotate, and vibration will occur in the case 212a because of the rotating motion of the eccentric weight 222. Incidentally, when a vibrator 212 is used, unlike the case of the vibration actuator 115 that was described in the first embodiment, the direction of the vibration generated by the vibrator 212 and the vibration form thereof will be will vary depending on the initial position of the eccentric weight 222 and the rotational direction of the DC motor 223. In order to generate the same vibration from the vibrator 212 each time, it is important to detect the position of the eccentric weight 222, and to always rotate the eccentric weight 222 in the same direction from the same position. Therefore, as illustrated in Fig. 6, the PDA 20 according to this embodiment has an encoder 213. The encoder 213 detects the rotational angle information of the DC motor 223, and outputs this information to the CPU 113. The CPU 113 selects the timing to stop applying the drive voltage to the DC motor 223, based on the rotational angle information provided from the encoder 213. For example, with the present embodiment, as illustrated in Fig. 7, the timing for stopping the application of the drive voltage to the DC motor 223 is determined such that the eccentric weight 222 will stop exactly at the 12 o'clock position with the rotating shaft 221 at the center. Incidentally, if a stepping motor is used in place of the DC motor 223, the position of the eccentric weight attached to the rotating shaft can be determined without using the encoder 213.

As described above, the direction of vibration generated by the vibrator 212 can be made to match the direction that is perpendicular to the surface of the touch panel 102 by controlling the position for stopping the eccentric weight 222. The vibration generated by the vibrator 212 is transferred through the liquid crystal display panel 103a to the touch panel 102. Therefore, the touch panel 102 vibrates in the direction perpendicular to the surface thereof, and the vibration will be transferred to the fingertip of the user that is operating the touch panel 102.

Fig. 9 is a diagram illustrating an example of the waveform of the drive voltage that is applied to the vibrator 212. Furthermore, Fig. 10 is a diagram illustrating an example of the vibration generated on the surface of the touch panel 102. With the vibrator 212, the rotational speed of the DC motor 223 changes depending on the drive voltage that is applied. Herein, if the rotational speed of the DC motor 223 matches the intrinsic frequency $f_1$ of the main body case 101 of the PDA 20 four matches the intrinsic frequency $f_2$ of the vibrator 212, the main body case 101 of the PDA 20 or the vibrator 212 will resonate.
Therefore, with the present embodiment, the drive voltage is applied to the vibrator 212 such that the rotational speed of the DC motor 223 matches the intrinsic frequency \( f_1 \) or the intrinsic frequency \( f_3 \). Therefore, as illustrated in Fig. 10, the touch panel 102 will vibrate in a direction perpendicular to the surface thereof at the intrinsic frequency \( f_1 \) or the intrinsic frequency \( f_3 \). Therefore, a larger vibration can be provided by a low drive power, and thus the power consumption of the PDA 20 can be conserved. Note, the waveform of the drive voltage is not restricted to the square waves illustrated in Fig. 9.

[B-2: Function of the second embodiment]

Fig. 11 is a flowchart for describing the operation of vibration control process 2 executed by the CPU 113 in the PDA 20 according to the same embodiment. The vibration controlling process 2 is executed by the CPU 113 every predetermined period of time, in the time period that operation input is allowed to the touch panel 102 and the operating keys 104a to 104c. Incidentally, the processes of the vibration controlling process 2 indicated by step S201 to S208 are the same as the processes of step S101 to S108 of the vibration control process 1 described in embodiment 1 (refer to Fig. 5), and therefore a description is omitted.

Incidentally, with the present embodiment, a vibrator 212 is used as the vibration generator, so the drive signal that is produced in the drive signal generating circuit 211 is a drive voltage, as illustrated in Fig. 9. When the drive voltage is applied, the vibrator 212 rotates the DC motor 223 at a rotational speed that matches the intrinsic frequency \( f_1 \) of the main unit case 101 or the intrinsic frequency \( f_3 \) of the vibrator 212. Therefore, the eccentric weight 222 will rotate, and vibration will be generated. The touch panel 102 and the operating keys 104a to 104c will vibrate in the direction perpendicular to the surface of the touch panel 102 by the vibration generated from the vibrator 212.

Furthermore, if the CPU 113 determines that the application time exceeds the specified time in step S208, or in other words, if the application time has reached 0.5 seconds, the process will proceed to Step S209. Next, the CPU 113 selects the timing to stop applying the drive voltage in order to stop the eccentric weight 222 at the same position each time, based on the rotational angle information provided from the encoder 213 (Step S209). In this embodiment, as illustrated in Fig. 7, the timing to stop applying the drive voltage is determined such that the eccentric weight 222 will stop exactly at the 12 o'clock position when the rotating shaft 221 is at the center.

Next, the CPU 113 instructs to stop application of the drive signal to the drive signal generating circuit 211 in accordance with the determined timing to stop application (step S210). Subsequently, the CPU 113 terminates the vibration control process 2. The drive signal generating circuit 211 stops application of the drive signal to the vibrator 212 when the CPU 113 instructs to stop application. Therefore, the eccentric weight 222 that is attached to the DC motor 223 of the vibrator 212 will stop at the same position each time. In this manner, the direction of the vibration generated by the vibrator 212 can be fixed by causing the eccentric weight 222 to stop at the same stopping position every time, and to rotate in the same direction from the same stopping position. Furthermore, the vibration generated by the vibrator 212 can be more finely controlled.

With the embodiment as described above, when the CPU 113 detects an operation input to the touch panel 102 and the operating keys 104a to 104c, the vibrator 212 is driven, and the touch panel 102 or the operating keys 104a to 104c are made to vibrate. Therefore, the PDA 20 can notify the user by vibration that an operation input has been received.
Furthermore, with the present embodiment, the eccentric weight 222 will always stop at the same position, and rotation in the same direction will be started from that stopping position. Therefore, the direction of vibration generated by the vibrator 212 can be fixed, and the vibration generated by the vibrator 212 can be more finely controlled. Therefore, when a touch operation is performed on the touch panel 102, or when a press down operation is performed on the thin operating keys 104a to 104c, the user can be provided with a pressing feel of the touch button or the operating keys by vibration stimulation. Application of this type of pressing feel or click feel will not be achieved if the stopping position of the eccentric weight 222 is not controlled in this manner, and cannot be achieved by conventional eccentric weighted motor.

[C: Third embodiment]
The present embodiment describes a mobile electronic apparatus that notifies the operator that execution of the process is completed when execution of the process specified by the operation input is completed. Incidentally, with this embodiment, parts that are shared with the first embodiment are assigned the same codes. Furthermore, a description of parts that are common with the first embodiment is omitted.

[C-1: Configuration of the third embodiment]
Fig. 12 is a perspective view illustrating an example of an appearance of a PDA 30 according to this embodiment. In this diagram, the PDA 30 has a display screen of a liquid crystal display panel 302a that faces the opening part of the main body case 301. Furthermore, a key input part 303 with a plurality of press down type operating keys is provided on an upper surface of the main body case 301.

Next, Fig. 13 is a block diagram illustrating an example of the hardware configuration of the PDA 30 illustrated in Fig. 12. As illustrated in this diagram, the PDA 30 has a display part 302, key input part 303, wireless communication part 304, memory 112, CPU (Central Processing Unit) 113, drive signal generating circuit 114, and a vibration actuator 115.

The PDA 30 has a function that performs data communication with other communication devices through a network such as WAN (Wide Area Network) or a LAN (Local Area Network). The wireless communication part 304 controls the wireless communication that is performed with a wireless base station of the WAN or LAN. The CPU 113 executes the vibration control process 3 (refer to Fig. 14), and drives the vibration actuator 115 by a drive signal generating circuit 114 to cause the main body case 301 to vibrate, when execution of a process specified by the operation input is completed.

Note, the vibration actuator 115 is the same vibration actuator 115 that was described in the first embodiment. Incidentally, with this embodiment, the vibration actuator 115 is attached to the inside of the main body case 301 on the opposite side as the surface where the display screen is provided, or in other words on the back surface of the PDA 30, and causes the main body case 301 to vibrate. Furthermore, this vibration is transferred to the hand of the user that is grasping the PDA 30.

[C-2: Function of the third embodiment]
Fig. 14 is a flowchart for describing the operation of vibration control process 3 executed by the CPU 113 in the PDA 30 according to the same embodiment. This vibration control process 3 is executed when execution of a process that requires a waiting time is requested by operation input. Herein, a process that requires waiting time can be downloading or uploading file data such as a reading process or the like of a webpage, a mail checking process for confirming whether or not there is an e-
mail, an application software starting process, copying or batch deleting file data, or initializing a data storage region in the memory 112, or the like.

As illustrated in this diagram, first, the CPU 113 executes the process indicated by the operation input (Step S301). Next, the CPU 113 determines whether or not the process being executed is completed (Step S302). If the process is not completed, the CPU 113 will return to step S301, and continue execution of the process. Furthermore, the CPU 113 will move to step S303 if it is determined that the process being executed is completed in step S302. The processes after step S303 are the same as the processes after step S102 of the vibration control process 1 described in embodiment 1 (refer to Fig. 5), and therefore a description is omitted.

With this control configuration, the CPU 113 drives the vibration actuator 115 by a drive signal generating circuit 114 to cause the main body case 301 to vibrate, when is detected that execution of a process specified by the operation input is completed. Therefore, the vibration is transferred to the hand of the user that is grasping the PDA 30.

Incidentally, if, for example, notification of completion of execution of a mail checking process is made by vibration, it is effective for the vibration to have a different form depending on whether there was an e-mail, or there was not an e-mail. Therefore, a control method where the form of the vibration differs depending on the results of the process that was executed is described below.

Fig. 15 is a flowchart for describing the operation of vibration control process 4 executed by the CPU 113 in the PDA 30 according to the same embodiment. As illustrated in this diagram, first, the CPU 113 executes the process indicated by the operation input (Step S401). Furthermore, the CPU 113 will move to step S403 if it is determined that the process being executed is completed in step S402.

Next, the CPU 113 acquires the execution results of the process that was executed in the step S401 (step S403). CPU 113 changes the count value of the specified time that determines the application time, or in other words the application time of the drive signal, based on the execution results (step S404). For example, when an e-mail check process is performed, the CPU 113 leaves the specified time at 0.5 seconds if there is not an e-mail, based on the check results. Furthermore, the specified time is set to 1.5 seconds if there is an e-mail.

Incidentally, the processes after step S405 are the same as the processes after step S303 of the vibration control process 3 described above (refer to Fig. 14), and therefore a description is omitted, but the CPU 113 changes the vibration time of the main body case 301 based on the process execution results.

With this embodiment, as described above, the CPU 113 drives the vibration actuator 115 when is detected that execution of a process specified by the operation input is completed, and causes the main body case 301 of the PDA 30 to vibrate. Therefore, the PDA 30 can notify the user by vibration that execution of the process specified by the operation input has been completed. Furthermore, with the present embodiment, the CPU 113 has a different vibration time for the vibration actuator 115 based on the execution results of the process. Therefore, the user can be aware of the execution results of the specified process by the vibration time, without looking at the screen information.

Incidentally, with the present embodiment, the case where the vibration time was changed based on the process execution results was described, but it is also possible to change the size of the vibration or the frequency of the vibration, or the like. In other words, the form of the vibration generated by the vibration actuator can be different depending on the execution results of the process. Furthermore, the present embodiment had a configuration that vibrated the entire main body case 301 of the
PDA 30. However, it is also acceptable to use a configuration where only the grasping part of the main body case 301 is made to vibrate when a user is grasping the PDA 30.

Furthermore, the present embodiment describe the case of a configuration where the main body case 301 of the PDA 30 was vibrated, or in other words, where vibration is provided to the hand of the user that is grasping the PDA 30. However, a configuration where a plurality of operating keys provided on the PDA 30 are vibrated, or in other words, a configuration where the vibration is provided to the fingertips that perform the operation input is also acceptable.

[D: Fourth embodiment]

This embodiment describes a mobile electronic apparatus where the position that is vibrated switches between the touch panel or the grasping part of the housing, based on whether or not the mobile electronic apparatus is being grasped by the user. Incidentally, with this embodiment, parts that are shared with the first embodiment are assigned the same codes. Furthermore, a description of parts that are common with the first embodiment is omitted.

[D-1: Configuration of the fourth embodiment]

Fig. 16 is a perspective view illustrating an example of the internal structure of a PDA 40 according to this embodiment. In this figure, the PDA 40 has a liquid crystal display panel 103a that overlays the touch panel 102, and the display screen of the liquid crystal display panel 103a faces an opening part of the main body case 401. Furthermore, the back surface of the liquid crystal display panel 103a has a vibration actuator 115a. The vibration actuator 115a vibrates the touch panel 102, and provides vibration to the fingertips of the user that performs the touch operation. On the other hand, a vibration actuator 115b is also provided on the inside of the main body case 401 on the opposite side as the surface where the display screen is provided, or in other words on the back surface of the PDA 40. This vibration actuator 115b provides vibration through the main body case 401 to the palm of the hand of the user that is grasping the PDA 40. Note, the vibration actuators 115a, 115b are the same as the vibration actuator 115 that was described in the first embodiment. Furthermore, a press down operating key 104a for inputting power source ON/OFF operations or the like is provided on the site surface of the main body case 401.

In this manner, the PDA 40 has two vibration actuators 115a, 115b. Furthermore, although omitted from the figure in Fig. 16, the PDA 40 has a touch sensor, and either one of the vibration actuators is driven to generate vibration depending on whether or not the user is grasping the PDA 40. The reason for performing this type of control is to prevent the occurrence of an unpleasing vibration sound when placed on a table during vibration, or to prevent the PDA 40 from moving during vibration when the main body case 401 of a PDA 40 that is placed on a table is vibrated.

Incidentally, the present embodiment describes the case where only the vibration actuator 115a is driven and vibration is provided to the fingertips that performed the touch operation, when the PDA 40 is not grasped by the user, but where only the vibration actuator 115b is driven and the palm of the user that is grasping the PDA 40 is vibrated when the PDA 40 is being grasped by the user, as one control example. However, for example, a configuration is also acceptable where vibration notification is performed by vibrating. The vibration actuators 115a, 115b when the PDA 40 is grasped by the user.

Next, Fig. 17 is a block diagram illustrating an example of the hardware configuration of the PDA 40 illustrated in Fig. 16. As illustrated in this diagram, the PDA 40 has a touch panel 102, display part 103, key input part 111, memory 112,
CPU 113, drive signal generating circuit 114, vibration actuators 115a, 115b, and a touch sensor 411.

The touch sensor 411 is a sensor that detects whether or not the PDA 40 is being grasped by the user, and provides the detection results to the CPU 113.

The memory 112 stores waveform data of the drive signals applied to the vibration actuators 115a, 115b. Herein, the frequency of the drive signal that is applied to the vibration actuator 115a is made to match the frequency that causes the liquid crystal display panel 103a provided on the touch panel 102 to resonate, or to match the frequency that causes the vibration actuator 115a itself to resonate. Furthermore, the frequency of the drive signal that is applied to the vibration actuator 115b is made to match the frequency that causes the main body case 401 of the PDA 401 to resonate, or to match the frequency that causes the vibration actuator 115b itself to resonate.

The CPU 113 executes the vibration control process 5 (refer to Fig. 18), and notifies the user by vibration that a touch operation has been received by the touch panel 102. Incidentally, with this embodiment, the CPU 113 causes vibration by driving only one of the two vibration actuators 115a, 115b, based on the detection results of the touch sensor 411.

The drive signal generating circuit 114 generates a drive signal for driving the vibration actuators 115a, 115b based on the waveform data supplied from the CPU 113. Furthermore, the drive signal generating circuit 114 applies a drive signal to the vibration actuators 115a, 115b based on instructions from the CPU 113.

[D-2: Function of the fourth embodiment]

Fig. 18 is a flowchart for describing the operation of vibration control process 5 executed by the CPU 113 in the PDA 40 according to the same embodiment. The vibration controlling process 5 is executed by the CPU 113 every predetermined period of time, in the time period that touch operation into the touch panel 102 is allowed.

As illustrated in the figure, first, the CPU 113 determines whether or not a touch signal from the touch panel 102 has been input (step S501). If the CPU 113 determines that a touch signal has not been input, the vibration control process 5 will be terminated. Incidentally, even if the CPU 113 determines that a touch signal has been input from the touch panel 102, the process of step S102 will not be performed and the vibration control process 5 will be terminated if the touch position on the touch panel 502 that was detected based on this signal is outside of the display region of a touch button that is displayed on the display screen, for example.

On the other hand, if the CPU 113 determines that a touch signal was input in step S501, the CPU then determines whether or not the user is grasping the PDA 40, based on the detection results of the touch sensor 411 (step S502). If the CPU 113 determines that a touch signal has not been input, the vibration control process 5 will be terminated. Incidentally, even if the CPU 113 determines that a touch signal has been input from the touch panel 102, the process of step S102 will not be performed and the vibration control process 5 will be terminated if the touch position on the touch panel 502 that was detected based on this signal is outside of the display region of a touch button that is displayed on the display screen, for example.

On the other hand, if the CPU 113 determines that a touch signal was input in step S501, the CPU then determines whether or not the user is grasping the PDA 40, based on the detection results of the touch sensor 411 (step S502). Furthermore, the CPU 113 determines that the vibration actuator to be driven is vibration actuator 115b, if it is determined that the PDA 40 is being grasped by the user (step S503). In other words, if the PDA 40 is being grasped by the user, the grasping part of the main body case 401 will be made to vibrate, and vibration will be provided to the palm of the user that is grasping the PDA 40.

On the other hand, the CPU 113 will determine that the vibration actuator to be driven is vibration actuator 115a, if it is determined that the PDA 40 is not being grasped by the user in step S502 (step S504). In other words, if the PDA 40 is not being grasped by the user, the vibration actuator 115a vibrates the touch panel 102, and provides vibration to the fingertips of the user that performs the touch operation.

Incidentally, the processes after step S505 are the same as the processes after step S102 of the vibration control process 1 described in embodiment 1 (refer to Fig.
5), and therefore a description is omitted, but the CPU 113 drives the vibration actuator that is determined by the process of step S503 or step S504, and provides vibration to either the touch panel 102, or the grasping part of the main body case 401.

With this embodiment as described above, the CPU 113 causes vibration by driving only one of the vibration actuators based on the detection results of the touch sensor 411. Therefore, the PDA can change the area that is vibrated to be either the touch panel 102 or the grasping part of the main body case 401, based on whether or not the PDA 40 is being grasped by the user.

Incidentally, with the present embodiment, a configuration where the user can specify the vibration actuator that is used during vibration notification. In this case, the CPU 113 performs a screen display for the user to specify the one or more vibration actuator that will be used during vibration notification. When the vibration actuator to be used is specified by an operation input from the user, the CPU 113 records the specified information in the memory 112. Furthermore, the CPU 113 determines that a touch signal has been input from the touch panel 102 in step S501, and then determines the vibration actuator to be driven based on the specified information that is stored in the memory 112.

Furthermore, Fig. 19 is a cross-section view illustrating an example of the internal structure of PDA 41 according to an alternate example of this embodiment. In this diagram, a liquid crystal display panel 103a where the touch panel 102 is overlaid on the display screen and the vibration actuator 115a is provided on the back surface is attached to the main body case 401 of the PDA 41 through an elastic member 451. This elastic member 451 may be rubber, urethane, sponge, or the like, for example, and as illustrated in Fig. 20, is attached to the circumferential edge part of the liquid crystal display panel 103a. This elastic member 451 is a member for causing the touch panel 102 and the liquid crystal display panel 103a to vibrate efficiently.

Incidentally, the elastic member 451 may be provided by dividing into a plurality of pieces on the circumferential edge part of the liquid crystal display panel 103a, as illustrated in Fig. 21 and Fig. 22. Furthermore, this elastic member 451 can also be configured using a spring or the like. With a configuration where the touch panel 102 and the liquid crystal display panel 103a are attached to the main body case 401 through the elastic members 451, 451a to 451f, as illustrated in Fig. 20 to Fig. 22, the vibration generated by the vibration actuators 115a, 115b can be efficiently provided to the touch panel 102 and the liquid crystal display panel 103a. Therefore, the drive power of the vibration actuator 115a can be reduced while providing the user with a larger vibration.

Furthermore, as illustrated in Fig. 23, a configuration is also possible where a vibration actuator 115cis provided so as to contact with both the back surface of the liquid crystal display panel 103a on which the touch panel 102 is overlaid, and the inside surface of the main body case 401 on the back surface side of the PDA 42. With this configuration, the same vibration can be provided to the fingertips that performed the touch operation on the touch panel 102 and to the hand that is grasping the PDA 42.

Furthermore, as illustrated in Fig. 24, the vibration actuator 115b may also be configured to directly vibrate the palm of the user that is grasping the PDA 43 by being placed such that a portion is exposed to the outside from the opening part that is provided in the main body case 401a. With this configuration, the user can efficiently be provided with the vibration generated from the vibration actuator 115b. Furthermore, in this case, the vibration actuator 115b can directly provide vibration to the user, and therefore control of the vibration can be more carefully controlled.
[E: Fifth embodiment]

This embodiment describes the location for placing the vibration generators that vibrate the touch panel.

Fig. 25 is a cross-section view for describing the internal structure of an ATM according to this embodiment. In this diagram, a liquid crystal display panel 501 is placed at an angle on a front surface of the main body device 50a of an ATM 50. A touch panel 502 is attached through a damper 503 to the display surface of a liquid crystal display panel 501. Two vibration actuators 115a, 115b are placed on an upper and lower part of the touchscreen of the touch panel 502. Furthermore, a main body cover 504 with an opening part is also provided on the outside of the touch panel 502.

Herein, the touch panel 502 is configured from a transparent and hard member such as a glass substrate, or the like. Furthermore, the damper 503 is a vibration absorbing member such as rubber, urethane, sponge, or the like, and is attached to the circumferential edge part of the touch panel 502. The damper 503 absorbs the vibrational component that is transferred to the liquid crystal display panel 501, of the vibrations that are generated by the vibration actuators 115a, 115b that are divided on the touch panel 502, and are members provided such that the vibration is not transferred to the liquid crystal display panel 501. Furthermore, this damper 503 plays a role for ensuring efficient vibration of the touch panel 502 that is placed on the liquid crystal display panel 501. Therefore, the damper 503 is preferably configured of an elastic body such as rubber or the like.

The vibration actuators 115a, 115b are the same vibration actuator 115 that was described in the first embodiment. Furthermore, the damper 503 and the vibration actuators 115a, 115b are provided on the outside of the display screen region of the liquid crystal display panel 501.

As illustrated in this figure, the liquid crystal display panel 501 is attached to the main body device 50a of the ATM 50. In contrast, the touch panel 502 is attached to the liquid crystal display panel 501 only through the damper 503, and a gap is provided between the touch panel 502 and the main body cover 504. Therefore, the touch panel 502 vibrates in a direction perpendicular to the surface of the touch panel 502 by the vibration generated from the vibration actuators 115a, 115b.

Incidentally, the control that generates the vibration by the vibration actuators 115a, 115b based on the touch operation to the touch panel 502 was described in the first embodiment, except for the point that a plurality of vibration actuators 115a, 115b are provided, and therefore the control can be performed similar to the vibration control process described in the first embodiment (refer to Fig. 5), and therefore a description is omitted. Furthermore, with this embodiment, the frequency of the drive signal that is applied to the vibration actuators 115a, 115b is a frequency that causes the touch panel 502 to resonate, or a frequency that causes the vibration actuators 115a, 115b themselves to resonate.

With the present embodiment described above, the ATM 50 can cause vibration only to the touch panel 502 by the vibration generated from the vibration actuators 115a, 115b. The vibration to the liquid crystal display panel 501 is absorbed by the damper 503. Therefore, the screen displays content of the liquid crystal display panel 501 will not become blurry, and therefore the display contents will be easy to view as compared to the case where the touch panel and the liquid crystal display panel are made to vibrate, as in the first embodiment.

Incidentally, as illustrated in Fig. 26, a configuration is also acceptable where the vibration actuators 115a, 115b are placed on the liquid crystal display panel 501 side of the touch panel 502. Furthermore, Fig. 27 is a cross-section view illustrating an example
of the internal structure of ATM 51 according to an alternate example of this embodiment. In this diagram, a touch panel 502 is attached through the two vibration actuators 115a, 115b to the display surface of a liquid crystal display panel 501 that is placed at an angle on the front surface side of the main body device 50a of the ATM 51.

Herein, the liquid crystal display panel 501 is attached to the main body device 50a of the ATM 51. In contrast, the touch panel 502 is attached to the liquid crystal display panel 501 only through the vibration actuators 115a, 115b, and a gap is provided between the touch panel 502 and the main body cover 504. Therefore, the touch panel 502 vibrates in a direction perpendicular to the surface of the touch panel 502 by the vibration generated from the vibration actuators 115a, 115b. Furthermore, the liquid crystal display panel is attached to the main body device 50a, and therefore there is almost no vibration even though there is contact with the vibration actuators 115a, 115b. Therefore, even with the configuration illustrated in Fig. 27, the same effects as the structure illustrated in Fig. 25 can be provided.

Furthermore, Fig. 28 to Fig. 31 are cross-section views illustrating an example of the internal structure of ATM 52, 53, 54, and 55 according to an alternate example of this embodiment. First, as illustrated in Fig. 28, a configuration is also possible where a liquid crystal display panel 501 where the touch panel 502 is overlaid on the display screen and the vibration actuators 115a, 115b are provided on the back surface is attached to the main body cover 504 through a damper 503. In this case, a gap is provided between the main body device 50a of the ATM 52 and the liquid crystal display panel 501. With this configuration, the touch panel 502 can vibrate in a direction perpendicular to the surface of the touch panel 502 by the vibration generated from the vibration actuators 115a, 115b. This elastic member 503 is a member for causing the touch panel 502 and the liquid crystal display panel 103a to vibrate efficiently.

Furthermore, as illustrated in Fig. 29, a configuration is also acceptable where the liquid crystal display panel 501 that is overlaid by the touch panel 502 on the display surface is installed on the main body cover 504 through the vibration actuators 115a, 115b. In this case, a gap is provided between the main body device 50a of the ATM 53 and the liquid crystal display panel 501. With this configuration, similar to the case illustrated in Fig. 28, the touch panel 502 can be made to vibrate by the vibration generated from the vibration actuators 115a, 115b.

Alternatively, as illustrated in Fig. 30, a configuration is also possible where a liquid crystal display panel 501 where the touch panel 502 is overlaid on the display screen and the vibration actuators 115a, 115b are provided on the back surface is attached to the main body device 50a of the ATM 54 through a damper 503. In this case, a gap is provided between the main body cover 504 and the liquid crystal display panel 501. With this configuration, the touch panel 502 can vibrate in a direction perpendicular to the surface of the touch panel 502 by the vibration generated from the vibration actuators 115a, 115b.

Furthermore, as illustrated in Fig. 31, a configuration is also acceptable where the liquid crystal display panel 501 that is overlaid by the touch panel 502 on the display surface is installed on the main body device 50a of the ATM 55 through the vibration actuators 115a, 115b. In this case, a gap is also provided between the main body cover 504 and the liquid crystal display panel 501. With this configuration, similar to the case illustrated in Fig. 30, the touch panel 502 can be made to vibrate by the vibration generated from the vibration actuators 115a, 115b.

Each of the alternate examples illustrated in Fig. 28 to Fig. 31 cause the touch panel 502 to vibrate with the liquid crystal display panel 501, but ATM 52 to 55 can
notify by vibration to the fingertips of the user that is performing a touch operation that the touch operation with regard to the touch panel 52 has been received.

Incidentally, with the present embodiment, the case was described where a liquid crystal display was used as the display. However, the display can also be a CRT, plasma display, EL (Electronic luminescence) display, and the like. Furthermore, the number of vibration actuators 115a, 115b is arbitrary. Furthermore, the damper 503 can also be configured using a spring or the like.

[F: Sixth embodiment]

The present embodiment describes an electronic apparatus that notifies the user that an operation input has been received, using vibration with different forms based on the type of operation input. Incidentally, this embodiment describes the fundamentals of the PDA 10 that was described in the first embodiment. Therefore, the parts that are common with the first embodiment are assigned the same codes. Furthermore, a description of parts that are common with the first embodiment is omitted.

[F-1: First example]

Fig. 32 is a diagram illustrating an example of the screen display of a PDA 10 according to the first example of this embodiment. As illustrated in the figure, a plurality of touch buttons “A” to “G” are displayed on the display screen of the PDA 10. When a user touches these touch buttons that are displayed on the screen using a fingertip, the touch operation is detected by the touch panel 102 that is overlaid on the display screen. Incidentally, the letter assigned to each touch button is simply assigned for identifying the touch button.

Next, Fig. 33 is a diagram illustrating an example of a waveform data table 112a that is stored in the memory of the PDA 10. As illustrated in the figure, area data using XY coordinate values to show the region that the touch button occupies on the touch panel 102 for each touch button that is displayed on the screen, and waveform data of the drive signal that is applied to the vibration actuator 115 when this touch button is pressed are stored in the waveform data table 112a.

Herein, the waveform of the drive signals that correspond to each touch button differ in amplitude and shape as illustrated in Fig. 34 to Fig. 37. Incidentally, the frequency $f_0$ of the drive signal in each figure is the frequency that causes residence in any one of the main body case 101 of the PDA 10, the liquid crystal display panel 103a that contains the touch panel 102, and the vibration actuator 115. The frequency data and the amplitude data that are necessary for generating the drive signal are stored as waveform data in the waveform data table 112a.

When a user touches the touch panel 102 of a PDA 10 with this configuration using a fingertip, the touch panel 102 detects the touch operation, and outputs the touch signal to the CPU 113. The CPU 113 determines the XY coordinate data of the touch position based on the touch signal, and specifies the touch button that has been pressed by referring to the waveform data table 112a. Next, the CPU 113 reads the waveform data for the drive signal that is assigned to the specified touch button from the waveform data table 112a.

Furthermore, the CPU 113 outputs the waveform data that was read to the drive signal generating circuit 114. Furthermore, simultaneously, the CPU 113 instructs the drive signal generating circuit 114 to generate a drive signal. The subsequent processes are the same as the processes after step S104 of the vibration control process 1 described in embodiment 1 (refer to Fig. 5), and therefore a description is omitted.
According to example 1 of this embodiment as described above, the CPU 113 first detects the touch position when a touch operation to the touch panel 102 is detected, and specifies the touch button that has been operated. Furthermore, the CPU 113 causes vibration to be generated by the vibration actuator 115 with a vibration form that corresponds to the type of the touch button. Therefore, the PDA 10 can have different forms of vibration that notify that a touch operation has been received, based on the touch button that was operated.

Incidentally, a configuration is also possible where vibration indicating that a touch operation was invalid is generated by the vibration actuator 115 if an area of the touch panel 102 that does not correspond to any touch button is pressed by the user. Furthermore, a configuration is also possible where the vibration form is varied by changing the vibration time and the number of vibrations.

Furthermore, the invention according to a first example of this embodiment can be applied even to an electronic apparatus that has a plurality of operating keys instead of a touch panel 102. In this case, the waveform data for each operating key is stored in the memory of the electronic apparatus. Furthermore, when the control part of the electronic apparatus detects that an operating key was operated, the control part reads the waveform data corresponding to the key that was operated from memory, and drives the vibration generator. With this configuration, the form of the vibration that notifies that the key operation has been received by the electronic device can be different, depending on the operated key.

[F-2: Second Example]

Fig. 38 and Fig. 39 are diagrams illustrating an example of the condition where an icon that is displayed on the display screen of the PDA 10 is dragged by a touch operation on the touch panel 102, and an operation of moving to the trash is performed. Incidentally, the trash referred to herein is an icon that provides a command to delete the data.

First, when the user selects the icon to be dragged by a touch operation on the touch panel 102, the CPU 113 of the PDA 10 detects the touch position, and specifies the command that is selected for the icon by the touch operation. As illustrated in Fig. 40, the memory 112 of the PDA 10 stores waveform data table 112b that stores the waveform data of the drive signal applied to the vibration actuator 115.

The CPU 113 reads the waveform data corresponding to the “selected icon” from the waveform data table 112, and drives the vibration actuator 115. Therefore, vibration showing that selection of the icon was performed is provided to the hand of the user that is grasping the PDA 10 or to the fingertip of the user that is performing the touch operation.

Furthermore, as illustrated in Fig. 38, when the user touches or moves the fingertip on the touch panel 102, and the selected icon is dragged, the CPU 113 specifies that the touch operation is a command to drag the icon. The CPU 113 reads the waveform data corresponding to the “drag” from the waveform data table 112, and drives the vibration actuator 115. Therefore, vibration indicating that dragging is taking place is provided to the user. For example, while dragging, a weak vibration is preferably continuously provided.

Furthermore, as illustrated in Fig. 39, when the dragged icon is overlaid on the trash, the CPU 113 specifies that the touch operation is a command to store the icon in the trash. Furthermore, the CPU 113 stores the icon in the trash, reads the waveform data corresponding to the “delete data” from the waveform data table 112b, and drives the vibration actuator 115. Therefore, vibration showing that the icon was deleted is provided to the user that is performing the touch operation.
As described above, according to example 2 of this embodiment, when the touch operation on the touch panel 102 is detected, the CPU 113 first specifies the type of command that is instructed by the touch operation. Furthermore, the CPU 113 causes vibration to be generated by the vibration actuator 115 with a vibration form that corresponds to the type of the specified command. Therefore, the PDA 10 can have different forms of vibration that notify that a touch operation has been received, based on the type of the command specified by the touch operation.

[F-3: Third example]

Fig. 41 is a diagram illustrating an example of the screen display of a PDA 10 according to the third example of this embodiment. As illustrated in this figure, a “scale” and a “knob” are displayed in order to adjust parameter values such as the sound volume level and the screen brightness, and the like. The user can change the position of the “knob” that is displayed on the screen by dragging by a touch operation on the touch panel 102.

First, when the user clicks on the “knob” by a touch operation on the touch panel 102, the CPU 113 of the PDA 10 specifies that the “knob” has been clicked. Furthermore, the CPU 113 provides vibration to the user indicating that the “knob” has been clicked.

Next, when the user touches or moves the fingertip on the touch panel 102, and drags the “knob” along the “scale”, the CPU 113 specifies that the “knob” has been dragged. Herein, the waveform data table 112c illustrated in Fig. 42 is stored in the memory 112 of the PDA 10 according to the third example of this embodiment. This waveform data table 112c divides the range that can be had by the parameter into a plurality of classifications, and stores the waveform data for the drive signal that is applied to the vibration actuator 115 for each classification.

The CPU 113 specifies the parameter value based on the position of the “knob” that was dragged, reads the waveform data corresponding to the current parameter value from the waveform data table 112, and drives the vibration actuator 115. Therefore, vibration corresponding to the parameter value is provided to the hand of the user that is grasping the PDA 10 or to the fingertip of the user that is performing the touch operation, while the “knob” is being dragged.

Note, as described below, a configuration that performs a waveform synthesis process of the drive signal is also acceptable. For example, if the parameter value is a value in a range of “0” to “100”, as illustrated in Fig. 43 to Fig. 45, the waveform data for each drive signal is stored in the memory 112, and examples include when the parameter value is “0” (Fig. 43), when the parameter value is “50” (Fig. 44), and when the parameter value is “100” (Fig. 45). If the current parameter value is “40”, the CPU 113 will synthesize both waveforms such that the ratio of waveforms with a parameter value of “0” will be “1”, and the ratio of waveforms with a parameter value of “50” will be “4”. Furthermore, the CPU 113 applies the synthesized waveform to the vibration actuator 115 as a drive signal.

Furthermore, a configuration is also possible where only the amplitude of the drive signal is changed proportional to the size of the parameter value, and thus the size of the vibration will change.

According to example 3 of this embodiment as described above, when the CPU 113 detects the touch operation that changes the parameter value on the touch panel 102, vibration is generated by the vibration actuator 115 with a vibration form that corresponds to the parameter value that was changed by the touch operation. Therefore, the PDA 10 can have different forms of vibration that notify that the click operation has been received, corresponding to the parameter value that was changed by the touch operation.
Incidentally, the invention according to the third example of this embodiment can be applied to an electronic apparatus with an operating element that continuously changes a parameter value (for example, a slide switch 993 illustrated in Fig. 78, and a dial switch 994 illustrated in Fig. 79, and the like). In this case, the controlling part of the electronic apparatus detects that the operating element was operated, vibration is generated by the vibration generator in a vibration form that corresponds to the parameter value that was changed by the operation of the operating element. Therefore, the form of the vibration that notifies that the operation of the operating element has been received by the electronic device can be different, depending on the parameter value that was changed by the operation of the operating element.

[G: Seventh embodiment]

The present embodiment describes an electronic apparatus that notifies the user that a touch operation has been received using vibration of different forms, based on the pressing level of the touch operation on the touch panel. Incidentally, this embodiment describes the fundamentals of the PDA 10 that was described in the first embodiment. Therefore, the parts that are common with the first embodiment are assigned the same codes. Furthermore, a description of parts that are common with the first embodiment is omitted.

With this embodiment, the touch panel of the PDA 10 can detect between two operating conditions, a condition where the fingertip of the user touches the touch panel (hereinafter in this embodiment, this operation is referred to as a touch operation) and a condition where the touch panel is pressed by the fingertips using a force above a predetermined pressing level (hereinafter in this embodiment, this is referred to as a pressing operation). The touch panel changes the type of touch signal that is output to the CPU 113 between touch operations and pressing operations.

Herein, the waveform data table 112d illustrated in Fig. 46 is stored in the memory 112 of the PDA 10 according to this embodiment. This waveform data table 112d corresponds to a screen display example of a touch button illustrated in Fig. 32. The area data of each touch button, and the waveform data that is applied to the vibration actuator 115 when the touch button is touch operated and when the touch button is pressing operated is stored in the waveform data table 112d.

With a PDA 10 having this configuration, when a touch operation is performed on the touch panel, the touch panel output to the CPU 113 a touch signal that indicates that a touch operation was performed. The CPU 113 determines the coordinate data of the touch position based on the touch signal, and specifies the touch button that has been pressed, by referring to the waveform data table 112d. Next, the CPU 113 reads the waveform data for the touch operation that is assigned to the specified touch button from the waveform data table 112d. Furthermore, the CPU 113 drives the vibration actuator 115 using the drive signal that was generated by the waveform data that was read. Furthermore, the same applies to the case where a pressing operation is performed on the touch panel. The CPU 113 reads the waveform data for the pressing operation that is assigned to the specified touch button from the waveform data table 112d, and drives the vibration actuator 115.

With this configuration, if, for example, the user does not press the touch panel by a fingertip, and moves the finger while in a condition of contact while searching for the position of the touch button, the PDA 10 will provide the user with a vibration for the touch operation that is assigned to the type of the touch button that is pressed by the fingertip. In other words, when the user is searching for the position of a touch button, a very weak vibration that differs for each type of touch
button will be provided to the user. On the other hand, when the user is searching for the desired touch button and a pressing operation is performed on the touch button, the PDA 10 will provide a vibration to the user for the pressing operation that is assigned to the type of touch button. In other words, when the user presses on the touch button, a vibration is provided to the user indicating that the operation has been received. This type of vibration notification control demonstrates a special effect when input of an operation is difficult to visually confirm. For example, this is useful when applied to a car navigation device or the like. Furthermore, even with a standard electronic apparatus, the effect is demonstrated under conditions late at night when lights are not turned on, or when the operation input is performed while searching by hand. According to this embodiment as described above, when the CPU 113 detects the touch operation on the touch panel 102, vibration is generated by the vibration actuator 115 with a vibration form that differs depending on whether the operation is a touch operation or a pressing operation. Therefore, the PDA 10 can have different forms of vibration that notify that an operation input has been received, based on the manner of the operating input on the touch panel.

Note, it is also possible to use a configuration that overlays a touch panel that receives a condition where the touch panel is touched by the fingertip of the user as an operation input and a touch panel where pressure by the fingertip of the user above a predetermined pressing level will be received as an operating input. Furthermore, the number of touch panels that are overlaid is not restricted to 2 panels.

[H: Eighth embodiment]

This embodiment describes an electronic apparatus with an audio mode where the fact that the operation input was received is notified by sound, and a vibration mode where the fact that the operation input has been received is notified by vibration, and the electronic apparatus switches between the notification modes based on the level of surrounding noise. Incidentally, with this embodiment, parts that are shared with the first embodiment are assigned the same codes. Furthermore, a description of parts that are common with the first embodiment is omitted.

[H-1: Configuration of the eighth embodiment]

Fig. 47 is a block diagram illustrating an example of the hardware configuration of the PDA 60. As illustrated in the figure, the PDA 20 has a touch panel 102, display part 103, key input part 111, memory 112, CPU 113, drive signal generating circuit 114, vibration actuator 115, microphone 601, noise measuring circuit 602, the sound generating circuit 603, and speaker 604.

The sound measuring circuit 602 measures the sound level based on the analog signal waveform of the noise around the PDA 60 obtained from the microphone 601, and output the measurement results to the CPU 113. The beep sound generating circuit 603 generates a drive signal for applying to the speaker 604, based on instructions from the CPU 113. This drive signal is applied to the speaker 604 to generate a beep sound.

The PDA 60 has an audio mode where the fact that the operation input was received is notified by a beep sound, and a vibration mode where the fact that the operation input has been received is notified by vibration. The CPU 113 executes the vibration control process 1 (refer to Fig. 48), and notifies the user by vibration or a beep sound that a touch operation has been received by the touch panel 102. At this time, the CPU 113 switches the notification mode between the sound notification mode and the vibration notification mode, based on the measurement results of the sound measuring circuit 602. The reason for switching the notification mode is that there is almost no effect
for notifying using a beep sound when the noise is above a predetermined level such as when out on the town. The CPU 113 selects at least the vibration notification mode when it is determined that the noise level around the PDA 60 is higher than a preset noise level.

[H-2: Function of the eighth embodiment]

Fig. 48 is a flowchart for describing the operation of the notification control process 1 executed by the CPU 113 in the PDA 60 according to this embodiment. The notification control process 1 is executed by the CPU 113 every predetermined period of time, in the time period that touch operation to the touch panel 102 is allowed.

As illustrated in the figure, first, the CPU 113 determines whether or not a touch signal from the touch panel 102 has been input (step S601). If the CPU 113 determines that a touch signal has not been input, the notification control process 1 will be terminated. On the other hand, if the CPU 113 determines that a touch signal was input, the CPU then determines whether or not the noise around the PDA 60 is above a preset noise level, based on the measurement results of the noise measuring circuit 602 (step S602). The CPU 113 selects at least the sound notification mode when it is determined that the noise level around the PDA 60 is not higher than a preset noise level (step S603). Furthermore, the CPU 113 drives the beep sound generating circuit 603 and causes the speaker to generate a beep sound (step S604), and notifies the user by a beep sound that a touch operation has been received.

On the other hand, the CPU 113 selects at least the vibration notification mode when it is determined in step S602 that the noise level around the PDA 60 is higher than a preset noise level (step S605). Furthermore, the CPU 113 drives the vibration actuator 115 through the vibration signal generating circuit 114, and notifies the user by vibration that a touch operation has been received. Incidentally, the processes after step S606 are the same as the processes after step S102 of the vibration control process 1 described in embodiment 1 (refer to Fig. 5), and therefore a description is omitted.

With the embodiment described above, the CPU 113 switches the notification mode for notifying that a touch operation has been received between a sound notification mode and a vibration notification mode, based on the surrounding noise (noise level). Incidentally, with the present embodiment, a configuration is acceptable where the user can specify the notification mode, and in this case, the CPU 113 provides a screen display to the user for specifying the notification mode to be used. When one or more of the sound notification mode and the vibration notification mode are specified as the notification mode to be used by the operation input of the user, the CPU 113 records the specified information in the memory 112. Furthermore, the CPU 113 determines that a touch signal has been input from the touch panel 102 in step S601, and then determines whether the notification mode is at least one of the sound notification mode or the vibration notification mode, based on the specified information that is stored in the memory 112.

Furthermore, as described in the first embodiment, this vibration actuator 115 can also be used as this speaker 604 (sound generating source), by applying an audio signal in the audible region to the coil 121 of the vibration actuator 115. Herein, the waveform of the drive signal for generating the vibration from the vibration actuator 115 is as illustrated in Fig. 49. Incidentally, in this figure, the frequency f₀ of the drive signal in each figure is the frequency that causes resonance in any one of the main body case 101 of the PDA 10, the liquid crystal display panel 103a that contains the touch panel 102,
and the vibration actuator 115 itself. Furthermore, the waveform of the drive signal for generating the sound from the vibration actuator 115 is as illustrated in Fig. 50.

Furthermore, the waveform of the drive signal for simultaneously generating sound and vibration from the vibration actuator 115 is as illustrated in Fig. 51, for example. The waveform illustrated in the diagram synthesizes the waveform for generating vibration illustrated in Fig. 49 and the waveform for generating sound illustrated in Fig. 50. The synthesis process for the waveform for generating vibration and the waveform for generating sound is performed in the drive signal generating circuit 114. Generating vibration and generating sound using only the vibration actuator 115 can be achieved by driving the vibration actuator 115 using the drive signals shown in Fig. 49 to Fig. 51.

Incidentally, when the vibration actuator 115 is provided a function as a sound generating source, a configuration is preferable where the volume of sound generated by the vibration actuator 115 is amplified using the liquid crystal display panel 103a and the main body case 101 and the like that transfer the vibration generated from the vibration actuator 115 as an acoustic loudspeaker mechanism. Furthermore, a configuration is also acceptable where an acoustic loudspeaker mechanism such as a cone paper or horn or the like is provided on the inside or outside of the vibration actuator 115. Furthermore, the sound that is generated from the vibration actuator 115 is not restricted to a notification sound such as a beep sound, and naturally can also include reproduction of music and human sounds or the like.

[I: Configuration of the ninth embodiment]

This embodiment describes an electronic apparatus that switches between the sound notifying mode and the vibration notifying mode described in the eighth embodiment, where switching is performed based on a beacon that is received from a wireless base station. Incidentally, with this embodiment, parts that are shared with the eighth embodiment are assigned the same codes. Furthermore, a description of parts that are common with the eighth embodiment is omitted.

[I-1: Configuration of the ninth embodiment]

Fig. 52 is a block diagram illustrating an example of the hardware configuration of the PDA 70. As illustrated in the figure, the PDA 70 has a touch panel 102, display part 103, key input part 111, memory 112, CPU 113, drive signal generating circuit 114, vibration actuator 115, beep noise generating circuit 603, speaker 604, and wireless communicating part 701.

This PDA 70 has a mobile device that is part of a wireless LAN with a plurality of base stations. The PDA 70 performs wireless communication with a base station that covers the wireless area where the PDA 70 exists, and receives packet communication service provided by the wireless LAN. Furthermore, this PDA 70 has an audio mode where the fact that the operation input was received is notified by a sound, and a vibration mode where the fact that the operation input has been received is notified by vibration.

The wireless communication part 701 controls the wireless communication that is performed with a wireless base station. The wireless communication part 701 superimposes data for packet communication, for example, on broadcast waves under the control of the CPU 113, two generate a wireless signal, and this wireless signal is transmitted to the base station. Furthermore, the wireless communication part 701 receives a wireless signal that is sent from the base station, demodulates the signal, and obtains data address to itself 70. Furthermore, the wireless communication part 701 receives a beacon that is periodically transmitted from the a station.
Herein, a beacon is a wireless signal that is periodically transmitted by the base station to the wireless area of that station, and for example, a beacon is transmitted at a rate of approximately several times per second. This beacon includes control bit data that specifies that the notification mode of the PDA 70 is one or more of sound notification mode and vibration notification mode. This control bit data is set to “0” when the notification mode of the PDA 70 is set to be only the sound notification mode, is set to “1” when the notification mode is set to be only the vibration notification mode, is set to “2” when the notification mode is set to be both the sound notification mode and the vibration notification mode, and is set to “3” when neither notification mode is to be used.

For example, a base station installed in a public facility such as a train station or a movie theater will transmit a beacon that includes the control bit data “1” in the wireless area of that station. Therefore, the notification mode of the PDA 70 that receives this beacon will be set to the vibration notification mode. Incidentally, for a base station provided in a movie theater, the notification mode of the PDA 70 is set to be vibration notification mode only during the time that the movie is playing, and can be set to both sound notification mode and vibration notification when a movie is not playing.

The CPU 113 stores the control bit data that is included in the beacon in the memory when a beacon is received from the base station that covers the wireless area where the PDA 70 exists. Furthermore, the CPU 113 determines the notification mode in accordance with the control bit data that is stored in the memory 112 when a touch operation is detected on the touch panel 102, and the user is notified that the touch operation was received by the selected notification mode. In this manner, the PDA 70 of the present embodiment is forced to specify the notification mode according to the Beacon that is received from the base station.

[I-2: Function of the ninth embodiment]

Fig. 53 is a flowchart for describing the operation of a beacon receiving process executed by a CPU in the PDA 70 according to the this embodiment. The beacon receiving process is executed by the CPU 113 when the PDA 70 receives the beacon that was transmitted from the base station. Incidentally, if the wireless area of the base station is partially overlapped by the wireless area of another base station, and the PDA 70 that is located in the overlap region receives beacons from both base stations, the CPU 113 will select the beacon with the strongest electromagnetic wave strength from the beacons that are received, and will execute the beacon receiving process based on that beacon.

As illustrated in this figure, first, the CPU 113 demodulates the beacon that is received by the wireless communication part 701 (step T101). Next, the CPU 113 extracts the control bit data that is included in the demodulated beacon (step T102). Furthermore, the CPU 113 stores the control bit data that was extracted in the memory 112 (step T103), and terminates the beacon receiving process. Incidentally, a configuration is also acceptable where in step T103, the CPU 113 compares the control bit data that was previously stored in the memory 112 with a control bit data that was just extracted, and if both pieces of control bit data do not match, the control bit data that was just extracted will overwrite the memory 112.

The CPU 113 executes the notification control process that notifies the user by vibration or a beep sound that a touch operation has been received by the touch panel 102. The notification control process of this embodiment is essentially the same as the notification control process 1 (refer to Fig. 48) that was described in the eighth embodiment, and therefore illustration in the drawings and a detailed description have been omitted, but the main points are as described below.
In other words, the CPU 113 determines the notification mode based on the control bit data that is stored in the memory 112 when a bit signal is received from the touch panel 102. For example, if the control bit data that is stored in the memory 112 is “0”, the notification mode will be set to the sound notification mode. Furthermore, the CPU 113 drives the beep sound generating circuit 603 and causes the speaker to generate a sound, and notifies the user by a beep sound that a touch operation has been received.

On the other hand, if the control bit data that is stored in the memory 112 is “1”, this CPU 113 will set the notification mode to the vibration notification mode. Furthermore, the CPU 113 drives the vibration actuator 115 through the vibration signal generating circuit 114, and notifies the user by vibration that a touch operation has been received.

With this embodiment as described above, the CPU 113 determines the notification mode for notifying that the touch operation has been received based on a beacon that was received from the base station. Therefore, the notification mode of the PDA 70 that exists in the wireless area of a base station can be set from the base station side. Therefore, the notification mode of the PDA 70 located in a public facility such as a movie theater or train station can automatically be switched from sound notification mode to vibration notification mode without the user changing the settings.

Note, as described in the eighth embodiment, a configuration is also possible where the vibration actuator also functions as a speaker 604. Furthermore, the invention according to this embodiment naturally can be used as a mobile phone or PHS (personal handyphone system) terminal that is used on a PDC (Personal Digital Cellular) type mobile packet communication network.

[J: 10th embodiment]

The present embodiment describes an electronic apparatus where the electronic apparatus has a function for acquiring the current position of itself, and switches between sound notification mode and vibration notification mode based on the current position of the device. Note, the PDA of this embodiment has the same hardware configuration as the PDA 70 that was described in the ninth embodiment (refer to Fig. 52), and therefore this same codes are used. Furthermore, a description of parts that are common with the ninth embodiment is omitted.

Furthermore, with the PDA 70 according to this embodiment, the wireless communication part 701 receives a beacon that is periodically transmitted from the base station. This beacon includes the base station ID for distinguishing the base station that transmitted the beacon. PDA 70 uses the base station ID that is included in the beacon as positional information indicating the current position of the device 70. However, the notification mode determination table 112e illustrated in FIG. 54 is stored in the memory 112. This notification mode determination table 112e stores the base station ID that indicates the area where the notification mode of the PDA 70 is the vibration notification mode. The base station ID that is stored in the notification mode determination table 112e is the base station ID that is placed in public facilities, for example where the sound notification mode would be a nuisance to the surrounding people. This notification mode determination table 112e is transmitted to the PDA 70 through the base station from a service control station of the wireless LAN.

With the PDA 70 having a configuration as described above, the CPU 113 executes the beacon receiving process when the beacon is received from the base station that covers the wireless area where the PDA 70 exists. In the beacon receiving process, the CPU 113 extracts the base station ID that is included in the
beacon that was demodulated by the wireless communication part 701, and stores the base station ID in the memory 112 as positional information of the PDA 70.

The CPU 113 executes the notification control process that notifies the user by vibration or a beep sound that a touch operation has been received by the touch panel 102. In the notification controlling process, the CPU 113 compares the base station ID showing the current position of the PDA 70 that is stored in the memory 112 with the base station ID that is stored in the information mode determination table 112e, if a touch operation is detected by the touch panel 102.

Furthermore, the CPU 113 notifies the user that a touch operation has been received based on the notification mode (for example the sound notification mode) that is set beforehand by the user if the base station ID showing the current position of the PDA 70 is not stored in the notification mode determination table 112e. Furthermore, the CPU 113 determines that the notification mode is the vibration notification mode and notifies the user that a touch operation has been received if the base station ID showing the current position of the PDA 70 is stored in the notification mode determination table 112e. Incidentally, control of the vibration actuator 115 and the drive signal generating circuit 114 during the vibration notification mode and control of the beep noise generating circuit 603 and the speaker 604 during the sound notification mode were previously described in the eighth embodiment, and therefore a description is omitted.

With this embodiment as described above, the CPU 113 determines the notification mode for notifying that the touch operation has been received based on the positional information indicating the current position of the PDA 70. Therefore, the notification mode of the PDA 70 located in a public facility such as a movie theater or train station can automatically be switched from sound notification mode to vibration notification mode without the user changing the settings.

Incidentally, this embodiment describes the case where the base station ID that is included in the beacon that was received from the base station is used as positional information. However, a configuration is also acceptable where the PDA 70 also has a GPS function (global positioning system), and the notification mode is determined using the positional information showing the latitude and longitude of the current position of the PDA 70 that was acquired by the GPS function. Furthermore, if the wireless LAN provides a positioning service for a mobile device, a configuration is also acceptable where the PDA 70 receives the positional information (latitude and longitude information) that indicates the current position of the device 70 from the base station, and determines the notification mode using this positional information. However, in this case, the area data that is stored in the information mode determination table 112e must be area data that is based on the latitude and longitude information rather than the base station ID.

Furthermore, the notification mode determination table 112e can be customized by the user. For example, the base station ID indicating the current position of the device 70 that is stored in the memory 112 can be additionally registered in the notification mode determination table 112e, by executing a registration process at a location where the user wants vibration notification mode.

Furthermore, as described in the eighth embodiment, a configuration is also possible where the vibration actuator also functions as a speaker 604. Furthermore, the invention according to this embodiment naturally can be used as a mobile phone or PHS terminal that is used on a PDC type mobile packet communication network.

[K: 11th embodiment]

The present embodiment describes an electronic apparatus that has a plurality of vibration generators, and controls the signal waveform of the drive
signal that is applied to the vibration generators based on the touch position on the touch panel. Incidentally, with this embodiment, parts that are shared with the fifth embodiment are assigned the same codes. Furthermore, a description of parts that are common with the fifth embodiment is omitted.

[K-1: Configuration of the 11th embodiment]

Fig. 55 is a diagram for describing an ATM according to this embodiment. As illustrated in this diagram, a total of 4 vibration actuators 115a, 115b, 115c, 115d are provided in the four corners on the back surface of the liquid crystal display panel that is overlaid with the touch panel 502. The reason for providing the plurality of vibration actuators 115a to 115d is that with electronic devices that have a large display screen such as an ATM or a personal computer or the like, providing sufficient vibration by a single vibration generator to the fingertip of the user that is performing the touch operation is difficult.

This embodiment describes the control for providing a larger vibration to the fingertips of the user while suppressing the power consumption required for the vibration notification by efficiently driving the vibration actuators 115a to 115d, when a plurality of vibration actuators 115a to 115d are used for vibration notification.

Fig. 56 is a block diagram illustrating an example of the hardware configuration of an ATM 90 according to this embodiment. As illustrated in this diagram, the ATM 90 has a touch panel 502, display part 901, memory 902, a drive signal generating circuit 903, vibration actuators 115a to 115d, and a CPU 904.

The touch panel 502 outputs a signal indicating the touch position on the touch panel 502 based on the touch operation to the CPU 904. Furthermore, the display part 901 has a liquid crystal display panel 501 and a drive circuit that controls the display of the liquid crystal display panel 501. The memory 902 stores programs and data and the like for controlling the ATM 90. Furthermore, the memory 902 stores waveform data of the drive signals applied to the vibration actuators 115a to 115d. Incidentally, with this embodiment, the waveform data shape of the drive signals applied to the vibration actuators 115a to 115d are the same. Furthermore, the frequency of the drive signal is made to match the frequency that causes the vibration actuators 115a to 115d to resonate.

The drive signal generating circuit 903 generates a drive signal for driving the vibration actuators 115a to 115d based on the waveform data and the phase data supplied from the CPU 904. Furthermore, the drive signal generating circuit 903 applies a drive signal to the vibration actuators 115a to 115d based on instructions from the CPU 904. The vibration actuators 115a to 115d are the same as the vibration actuator 115 that was described in the first embodiment.

The CPU 904 controls each part of the devices that are connected through a bus 905 by executing a program that is stored in the memory 902. The CPU 904 executes the vibration control process 6 (refer to Fig. 57 and Fig. 58), and drives the vibration actuators 115a to 115d by a drive signal generating circuit 903 to cause the touch panel 502 and the liquid crystal display panel 501 to vibrate, when an operation input is detected from the touch panel 502.

[K-2: Function of the 11th embodiment]

Fig. 57 and Fig. 58 are flowcharts for describing the operation of vibration control process 6 executed by the CPU 904 in the ATM 90 according to the same embodiment.
The vibration controlling process 6 is executed by the CPU 904 every predetermined period of time, in the time period that touch operation to the touch panel 502 is allowed. As illustrated in Fig. 57, first, the CPU 904 determines whether or not a touch signal from the touch panel 502 has been input (step S701). If the CPU 904 determines that a touch signal has not been input, the vibration control process 6 will be terminated. Furthermore, the CPU 904 specifies the touch position (XY coordinate values) on the touch panel 502 based on the touch signal when it is determined that a touch signal is input (step S702). Incidentally, the CPU 904 can terminate the vibration control process 6 without moving to the process of step S703 if it is determined that the position of the touch on the touch panel 502 is outside of the display region of the touch buttons that are displayed on the display screen.

Next, the CPU 904 determines the positional relationship between the touch position and each of the vibration actuators 115a to 115d by calculating the straight line distance between the touch position and each of the vibration actuators 115a to 115d, as illustrated in Fig. 55. Furthermore, the CPU 904 analyzes the vibration using as parameters the elastic force of the damper 503 and the material of the liquid crystal display panel 501 where the vibration actuators 115a to 115d are provided, as well as the positional relationship of the touch position and each of the vibrational actuators 115a to 115d. Note, a configuration is also possible where the result data of the vibration analysis based on each of the touch positions on the touch panel 502 are stored in the memory 902 beforehand, and this vibration analysis result data is used. With this configuration, the vibration analysis based on the touch position does not require calculations in real time. Furthermore, the CPU 904 calculates the phase of the drive signal that is applied to the vibration actuators 115a to 115d such that the amplitude of the vibration at the touch position is a maximum, based on the mutual interference of the vibration waves generated from the vibration actuators 115a to 115d (step S704).

Furthermore, the CPU 904 reads the waveform data of the same drive signal that was applied to each of the vibration actuators 115 from the memory 902 (step S705). Next, the CPU 904 outputs to the vibration signal generating circuit 903 the phase data for the vibration actuators 115a to 115d that was calculated in step S704 and the waveform data that was read from the memory 902. Furthermore, at this time, the CPU 904 instructs the drive signal generating circuit 903 to generate a drive signal (step S706). The drive signal generating circuit 903 generates a drive signal that is applied to the vibration actuators 115a to 115d using the phase data and the waveform data supplied from the CPU 904. The processes after step S707 are the same as the processes after step S104 of the vibration control process 1 (refer to Fig. 5) that was described in the first embodiment, except for the point that a plurality of vibration actuators 115a to 115d are driven, and therefore an explanation is omitted, but the vibrational waves with a phase that was calculated in step S704 from the vibration actuators 115a to 115d is provided to the touch panel 502 in the vibration control process 6.

With the present embodiment as described above, the CPU 904 adjusts the phase of the drive signal that is applied to the vibration actuators 115a to 115d such that the amplitude of the vibration at the touch position on the touch panel 502 is a maximum, based on the mutual interference of the vibration waves generated from the vibration actuators 115a to 115d. Therefore, the ATM 90 efficiently drives the vibration actuators 115a to 115d, and can provide to the fingertips of the user a larger vibration while suppressing the power consumption that is required for vibration notification.

Incidentally, this embodiment describes the case where the phase of the drive signals applied to the vibration actuators 115a - 115d are the adjusted. However, a
configuration is also possible where the amplitude or the like of the drive signal is adjusted instead of the phase. Furthermore, the number of vibration actuators provided is not restricted to 4. Furthermore, the vibration actuators can be provided on the touch panel 502, for example, or can be provided interposed between the liquid crystal display panel 501 and the touch panel 502 as illustrated in Fig. 27.

Furthermore, a configuration is also possible where the area of the touch panel 502 is divided by the units of the touch area when the fingertip touches the touch panel 502, and the phase data of the drive signal that is applied to the vibration actuators 115a to 115d when the classified region is touch operated is calculated beforehand, the data table where the calculation results are recorded is stored in the memory 902. With this configuration, the phase of the drive signal that is applied to the vibrational actuators 115a to 115d based on the touch position does not need to be calculated in real-time. Therefore, response rate of the vibration notification for a touch operation can be increased.

Furthermore, Fig. 59 and Fig. 60 are cross-sectional diagrams for describing an ATM according to an alternate example of this embodiment. The surface of the touch panel 502 of the ATM according to this alternate example is laminated with a deformation layer 550 that is coated with a particular film that can deform, made of a highly viscous liquid or gel, or a fine powder. Incidentally, the color of the liquid, gel, or powder substance that forms the deformation layer 550 as well as that of the protective film is clear.

With this ATM, when the vibration actuators 115a to 115d are driven, waves will occur on the surface of the deformation layer 550 because of the vibration produced from the vibration actuators 115a to 115d. Furthermore, the CPU of the ATM adjusts the phase of the drive signal that is applied to the vibration actuators 115a to 115d such that the height of the surface of the deformation layer 550 at the touch position is higher than for an untouched, because of the mutual interference of the waves generated by the vibration actuators 115a to 115d. Therefore, as illustrated in Fig. 59, the area of the touch position on the surface of the deformation layer 550 can be raised.

Alternatively, conversely, the CPU of the ATM adjusts the phase of the drive signal that is applied to the vibration actuators 115a to 115d such that the height of the surface of the deformation layer 550 at the touch position is lower than for an untouched, because of the mutual interference of the waves generated by the vibration actuators 115a to 115d. Therefore, as illustrated in Fig. 60, the area of the touch position on the surface of the deformation layer 550 can be lowered. With this alternate example, the user can be notified that the touch operation has been received by the change in the layer thickness of the deformation layer 550. Furthermore, by drive controlling the vibration actuators 115a to 115d such that the surface part of the touch position recesses in the deformation layer 550, the feel of pressing a touch button can be provided to the user that is performing the touch operation.

Incidentally, with this alternate example, the amplitude and the shape of the waveform, as well as the vibration direction and the phase of the vibration generated by the vibration actuators 115a to 115d are important elements for performing the drive control of the vibration actuators 115a to 115d. Therefore, it is preferable that the area of the touch panel 502 is divided by the units of the touch area when the fingertip touches the touch panel 502, and the waveform data of the drive signal that is applied to the vibration actuators 115a to 115d when the classified region is touch operated is calculated beforehand, the data table where the calculation results are recorded is stored in the memory.
An electronic apparatus having a plurality of vibration generators similarly to the 11th embodiment, which switches the driving vibration generator based on a touch position on a touch panel is described in the present embodiment. Note that in the present embodiment, the same codes are used for portions that are common with the 11th embodiment. Furthermore, descriptions of the portions that are common with the 11th embodiment are omitted.

[L-1: Configuration of the 12th embodiment]

Fig. 61 is a diagram for describing an ATM according to the present embodiment of the present invention. As illustrated in the same drawing, a total of 4 vibration actuators 115a to 115d on four corners of a back surface of the liquid crystal display panel 501 on which the touch panel 502 is overlaid. Furthermore, as illustrated in the same drawing, a region where touch operation is possible on the touch panel 502 is divided into a plurality of regions A1 through A5. In the present embodiment, when vibration notification is performed, the driving vibration actuator switches from the vibration actuators 115a through 115d based on the region of the regions A1 through A5 in which the touch position on the touch panel 502 is included.

The hardware configuration of the ATM according to the present embodiment is similar to the configuration illustrated in FIG. 56 in the aforementioned 11th embodiment. However, the drive target determination table 902a illustrated in FIG. 62 is stored in the memory 902. As illustrated in the same drawing, area data using XY coordinate values to show the divided regions A1 through A5 on the touch panel 502 and identification information of the driving vibration actuator one the divided regions are touch operated are stored in the drive target determination table 902a. Notes that in the same drawing, codes attached to the vibration actuator 115a through 115d are used as identification information of the vibration actuators.

According to the drive target destination table 902a, when region A1 on the touch panel 502 illustrated in FIG. 61 is touch operated, only vibration actuator 115a is driven for example. Furthermore, when region A5 on the touch panel 502 is touch operated, all vibration actuators 150a through 115d are driven.

When touch operation on the touch panel 502 is detected, the CPU 904 detects the touch position and determines the driving vibration actuator while referencing the drive target determination table 902a. Furthermore, the CPU 904 drives the determined vibration actuator through the drive signal generating circuit 903 to vibrate the touch panel 502 and liquid crystal display panel 501.

[L-2: Operation of the 12th embodiment]

Fig. 63 is a flowchart for describing the operation of vibration control process 7 executed by a CPU904 in the ATM according to the present embodiment. The vibration control process 7 is executed every predetermined cycle by the CPU 904 in a period where touch operation on touch panel 502 is permitted.

As illustrated in the same drawing, first, the CPU 904 determines whether or not a touch signal is input from the touch panel 502 (step S801). When the CPU 904 determines that a touch signal is input, the CPU completes the vibration control process 7. Furthermore, when the CPU 904 determines that eight touch signal is not input, the CPU specifies the touch position (XY coordinate value) on the touch panel 502 based on the touch signal (step S802).

Next, the CPU 904 specifies the divided region in which the touch position is included while referencing the drive target determination table 902a illustrated in
FIG. 62, and determines the driving vibration actuator (step S803). Thereafter, the CPU 904 reads from the memory 902 waveform data of the drive signal for driving the determined vibration actuator (step S804). Furthermore, the CPU 904 outputs the waveform data read from the memory 902 and identification information of the vibration actuator determined in the aforementioned step S803 to the drive signal generating circuit 903. Furthermore, at this time, the CPU 904 instructs the drive signal generating circuit 903 to generate a drive signal (step S805). Note that processes after step S806 are the same as the processes after step S104 in vibration control process 1 (referred to FIG. 5) described in the first embodiment with the exception of the point where only the vibration actuator specified from the plurality of vibration actuators 115a through 115d, and therefore, descriptions are omitted.

According to the present embodiment as described above, CPU 904 switches the driving vibration actuator based on the touch positions on the touch panel 502. Therefore, the ATM can efficiently drive the vibration actuators 115a through 115d based on the touch position on the touch panel 502.

Note that in the present embodiment, the region on the touch panel 502 is divided into a plurality of regions in advance, and identification information of the vibration actuator driving when the divided region is touch operated is recorded in the memory 902 for the divided regions. However, configuration may be such that when touch operation on the touch panel 502 is detected for example, the touch position thereof is detected, the distance between the touch position and the vibration actuators 115a through 115d is calculated, and the nearest vibration actuator is driven.

[M: 13th Embodiment]

In the present embodiment, a preferred vibration generator is described using the 1st through 12th embodiments. The vibration actuator uses a permanent magnet as the movable weight, and is a permanent magnet movable type linear oscillatory actuator that generates vibration by causing the movable weight to linearly reciprocally move by electromagnetic force.

[M-1: First Example]

FIG. 64 is a cross-section view illustrating an example of the internal structure of the vibration actuator 950 according to the first example of the present embodiment. In the same drawing, the vibration actuator 950 has a coil 962, a movable weight 963 (weighted body), a braking member 964, and spring 966 inside a case 961. Note that in the same drawing, the vibration subject body on which the vibration actuator 950 applies vibration is provided in a position facing the coil 962 while interposing the case 961. Furthermore, the case 961 is sealed, and functions as a magnetic shield. In order to provide this function of a magnetic shield to the case 961 in this manner, the case 961 is formed from a conductive substance that is grounded or that is equipotential, or the case 961 is formed from a magnetic body with high magnetic permeability.

The coil 962 is a coil having an essentially cylindrical shape as illustrated in the same drawing, and is secured to the case 961. When the vibration actuator 950 is driven, an alternating current (drive signal) is applied to the coil 962.

The movable weight 963 is positioned on an upper part of the coil 962, and is an essentially cylindrical weight formed by a permanent magnet. An annular concave part where an upper end part of the coil 962 is formed on a lower surface of the movable weight 963. The movable weight 963 is supported in the space formed inside the case 961 by a spring 966 in a condition that can reciprocally move linearly in the vertical direction of the figure. As illustrated in the same drawing, one end of the
spring 966 is connected to the case 961 (base member) that contacts with the liquid vibration subjected body, and the other end is connected to the movable weight 963. Note that a supporting member configured using an elastic body such as string shaped rubber or the like may also be used in place of the spring 966.

The movable weight 963 reciprocally moves linearly in the vertical direction of the figure by the magnetic force generated from the coil 962 when the drive signal is applied to the coil 962. Vibration acceleration is generated in a portion of the case 961 that is connected to the spring 966 as a reactive force to the reciprocal movement of the movable weight 963. Note, in addition to the reactive force of the reciprocal motion, a vibration component that is transferred through the spring 966 from the movable weight 963 is also applied, in conjunction with the reciprocal movement of the movable weight 963 to the portion of the case 961 that is connected to the spring 966, but the basic principle of generating vibration in the vibration actuator 950 uses the vibration acceleration generated as the reactive force of the reciprocal movement of the movable weight 963.

The braking member 964 has a brush 965 that always contacts a side surface of the movable weight 963. The brush 965 is designed so as to provide appropriate contact resistance on the side surface of the movable weight 963. Herein, when a drive signal is applied on the coil 962 such that the movable weight 963 performs reciprocal motion, the contact resistance applied on the movable weight 963 by the brush 965 mostly does not hinder reciprocal motion thereof. On the other hand, when drive signal application to the coil 962 is stopped, reciprocal motion of the movable weight 963 is quickly stopped by the contact resistance.

In other words, the braking member 964 functions as a break for quickly stopping reciprocal motion of the movable way 963 when drive signal application to the coil 962 is stopped. Note that instead of the brush 965, a sponge or member formed by urethane, felt, rubber, or the like may be used.

FIG. 65 through FIG. 67 are plan views illustrating placement example of the braking member 964, which illustrate a case viewing the inside of the vibration actuator 950 from above in the cross-sectional view illustrated in FIG. 64. FIG. 65 illustrates an example where three braking members 964a are placed at 120° intervals around the movable weight 963. Furthermore, FIG. 66 illustrates an example where two braking members 964b are arranged to be facing while interposing the movable weight 963. Furthermore, FIG. 64 illustrates an example where one cylindrical braking member 964c is placed such that the periphery of the movable weight 963 is enclosed.

Herein, when the braking member 964a is provided on one location on the periphery of the movable weight 963 for example, contact resistance is applied on the movable weight 963 from only one direction that contacts the brush 965a of the braking member 964a. Therefore, the posture of the movable weight 963 collapses during reciprocal motion, and fluctuation occurs in the vibration direction generated from the vibration actuator 950. Furthermore, even when drive signal application is stopped, contact resistance is applied on the movable weight 963 by the brush 965a from one direction, and therefore, the posture of the movable way 963 collapses, and thus reciprocal motion cannot be quickly stopped. Furthermore, even when drive signal application is stopped, a large fluctuation in the driving direction occurs.

Based on the aforementioned, arrangement of the braking members 964a through 964b where the contact resistance of the brushes 965a through 965c is uniformly applied from the periphery on the movable weight 963 is required as illustrated in FIG. 65 through FIG. 67. Furthermore, in order to suppress abrasions from the brush 965a through 965c due to aging or deformation of the braking
members 964a through 964c, increasing the contact surface of the brushes 965a through 965c with the movable weight 963 as much as possible is effective within a range that does not hinder the reciprocal motion of the movable weight 963.

For a vibration actuator without the braking mechanism for the movable weight 963, when drive signal application of period T1 illustrated in FIG. 68 is stopped for example, the reciprocal motion of the movable weight 963 does not immediately stop as illustrated in FIG. 69, and thus unnecessary vibrations remain. Therefore, the vibration actuator does not provide the user operating feel such as a clicking feel that must clearly exhibit vibration intensity within a short period of time or the like by vibration stimulation. Furthermore, variation during vibration and during non-vibration cannot be made clear at the same time.

According to the first example of the present embodiment with regard thereto, for the vibration actuator 950, when the drive signal application illustrated in FIG. 68 is stopped, the reciprocal motion of the movable weight 963 is quickly stopped by the contact resistance of the braking member 964. Therefore, unnecessary vibration does not remain, and a “tight” operation feel such as a clicking feel can be provided to a user by vibration stimulation. Furthermore, variation during vibration and during non-vibration can be made clear.

[M-2: Second Example]

FIG. 71 is a cross-section view illustrating an example of the internal structure of the vibration actuator 951 according to the second example of the present embodiment. In the same drawing, the vibration actuator 951 has the coil 962, movable weight 963, spring 966, braking member 971, and braking coil 972 inside the case 961. Note that in the same drawing, the vibration subjected body is provided in a position facing the coil 962 while interposing the case 961. Furthermore, the case 961, coil 962, and movable weight 963 are the same as the first example of the present embodiment, and therefore, descriptions are omitted.

The braking member 971 has a braking surface 971a having a surface covered by rubber, and a magnet 971b. Furthermore, the spring 973 pulling the braking surface 971a to a side surface of the movable weight 963 is attached to the braking member 971. The braking surface 971a of the braking member 971 is pushed toward a side surface of the movable weight 963 by a force of the spring 973, in a period when a drive signal is not applied on the braking coil 972. On the other hand, in the braking member 971, the magnet 971b is pulled toward the braking coil 972, and therefore, the braking surface 971a is separated from a side surface of the movable weight 963, in a period when a drive signal is applied to the braking coil 972. Note that instead of rubber, a sponge, urethane, felt, brush, or the like may be attached to a surface of the braking surface 971a.

FIG. 72 is a diagram illustrating a circuit configuration for applying a drive signal on the coil 962 and braking coil 972. In the same drawing, a vibration generator 974 generates a drive signal for driving the coil 962. FIG. 73 illustrates a waveform example of the drive signal vibrating from the vibration generator 974. An alternating current waveform as illustrated in the same drawing is applied on the coil 962 such that the movable weight 963 performs reciprocal motion. Furthermore, a brake control circuit 975 generates a drive signal that is applied to the braking coil 972. The brake control circuit 975 monitors the drive signal vibrating from the vibration generator 974, and as illustrated in FIG. 74, outputs a square waveform drive signal to the braking coil 972 only during period T2 when the drive signal is vibrated from the vibration generator 974.

Therefore, the drive signal is applied to the braking coil 972 from the brake control circuit 975 in the period where the vibration generator 974 applies a drive
signal on the coil 962, and therefore, the braking surface 971a of the braking member 971 is separated from a side surface of the movable weight 963. Furthermore, in the period, the drive signal is supplied to the coil 962 from the vibration generator 974, and therefore, the movable weight 963 performs reciprocal motion. On the other hand, when drive signal application from the vibration generator 974 to the coil 962 is stopped, drive signal application from the brake control circuit 975 to the braking coil 972 is also stopped. Therefore, the braking surface 971a of the braking member 971 is pushed to a side surface of the movable weight 963, and thus reciprocal motion of the movable weight 963 is quickly stopped. Therefore, the same effects as the first example of the aforementioned present embodiment are achieved.

M-3: Third Example

FIG. 75 is a cross-section view illustrating an example of the internal structure of the vibration actuator 952 according to the third example of the present embodiment. In the same drawing, the vibration actuator 952 has the coil 962, movable weight 963, and spring 966 inside the case 961. The coil 962, movable weight 963, and spring 966 are the same as the first example of the present embodiment. Furthermore, the vibration subjected body in the same drawing is provided in contact with the case 961 at a position facing the coil 962 while interposing the case 961.

Next, FIG. 76 is a diagram illustrating a circuit configuration for applying a drive signal on the coil 962. The vibration generator 974 illustrated in the same drawing is the same as the second example of the present embodiment, and therefore, descriptions are omitted. A control circuit 91 performs switching control of switches SW1, SW2 at two locations inside a switch circuit 982. The control circuit 981 monitors the drive signal (refer to FIG. 73) vibrating from the vibration generator 974, and as illustrated in FIG. 77, outputs a “Hi” level CTRL signal only during period T2 when the drive signal is vibrated from the vibration generator 974. When the CTRL signal supplied from the control circuit 981 is at a “Hi” level, the switches SW1, SW2 of the switch circuit 982 connect the vibration generator 974 and coil 962. Therefore, when the CTRL signal is at a “Hi” level, a drive signal is applied to the coil 962 from the vibration generator 974 such that the movable weight 963 performs reciprocal motion.

On the other hand, when the CTRL signal supplied from the control circuit 91 is at a “Low” level, in other words, when drive signal application to the coil 962 from the vibration generator 974 is stopped, the switches SW1, SW2 of the switch circuit 982 switches a contact point illustrated in FIG. 76 to short the coil 962. Therefore, reciprocal motion of the movable weight 963 can be quickly stopped when the drive signal application is stopped by an electromagnetic braking function. Therefore, the same effects as the first example of the aforementioned present embodiment are achieved. So long as the vibration actuators 950 through 952 described in the first example through third example of the present embodiment described above is used as a vibration generator of the electronic apparatus in the 1st through 12th embodiments, vibrations provided to a user can be more preferably controlled.

This is because first, a braking mechanism is provided in the vibration actuators 950 through 952 in the first embodiment. Therefore, vibration intensity must be clearly exhibited within a short period of time, for example, operating feel such as a clicking feel or the like can be clearly provided to a user.

Second, the vibration actuators 950 through 952 are linear oscillatory actuators, and therefore, directional precision of the generated vibration is high. Furthermore, third, the vibration actuators 950 through 952 store the coil 962 and movable weight 963 inside the case 961 sealed as a magnetic shield, and therefore is influenced by a magnetic force.
from peripheral electronic components or the like. Therefore, shifting does not occur in
the vibration direction generated from the vibration actuators 950 through 952, or
distortion in the amplitude shape of the vibration does not occur. Based on the
aforementioned second and third advantages, vibrations generated from the vibration
actuators 950 through 952 can be more finely controlled. Therefore, if touch operation on
the touch panel is performed, or if a pressing operation of a thin operating key is
performed, a pressing feeling or clicking feeling can be provided to a user by a vibration
stimulation. Furthermore, the vibration actuators 950 through 952 do not malfunction due
to a magnetic force with regard to periphery all electronic components or the like.

Fourth, the vibration actuators 950 through 952 are formed in a single package.
Therefore, as compared to a case where a vibration actuator member is separately
installed, first, there is almost no good or bad precision for attaching the permanent
magnet and coil. Furthermore, the installation precision of the permanent magnet and the
coil will not easily deteriorate by changing over time. Therefore, vibrations can be
generated with stable precision from the vibration actuators 950 through 952.
Furthermore, incorporation into the electronic apparatus is simple. Furthermore, the
vibration actuators 950 through 952 can provide a sufficiently large vibration to a
vibration subjected member, even if a supporting member such as a housing or electronic
apparatus main body supporting a vibration subjected member (such as a touch panel,
liquid crystal display panel, or the like) on which the vibration actuators 950 through 952
are installed, or the like is not reliably secured, or if the mass of the supporting body is not
sufficiently large with regard to the vibration subjected member. This is particularly
favorable when using a light weight electronic apparatus or a mobile electronic apparatus.

In the fifth embodiment, for the vibration actuators 950 through 952, a sound
signal within an audible band is applied on the coil 962 such that the vibration
actuators 950 through 952 can be used as a sound generating source. In this manner,
the function of both a vibration generator and a sound generating source can be
achieved, and thus the installation space of the components can be greatly conserved
in small electronic apparatuses such as mobile phones, pagers and the like.

Note that the vibration actuators 950 through 952 illustrated in examples 1
through 3 of the present embodiment have a configuration wherein the vibration
actuators 950 through 952 are sealed by the case 115a that has a magnetic shielding
effect, but are not necessarily sealed by case 961. Furthermore, the spring 966 that
supports the movable weight 963 may be directly connected to the back surface of
the liquid crystal display panel 103 rather than the case 115a.

[N: Alternate examples]
The embodiments of the present invention were described, but the
embodiments are merely examples, and various modifications are possible within
the scope without deviating from the object of the present invention. For examples,
the following can be considered as a modification.

[Alternate example 1]
The aforementioned first embodiment can have a configuration wherein a
plurality of various types of waveform data are stored in the memory 112, and among
the plurality of various types of waveform data, the CPU 113 reads the waveform data
that was previously specified by operation input by the user, and drives the vibration
actuator 115. With such a configuration, the form of vibration used for notification
can have more variations. For example, vibration time, vibration greatness, period of
vibration intensity, and the like can be arbitrarily changed.
Furthermore, sample data of a drive signal waveform is stored in the memory 112, and the drive signal generating circuit 114 can have a configuration wherein drive signal is generated by changing the sample data to D/A (Digital/Analog).

[Alternate example 2]
The first through third embodiments can have a configuration wherein the user can specify enabling/disabling of the notification function by vibration. In this case, the CPU 113 performs screen display to allow the user to specify the enabling or disabling of the notification function by vibration. When the enabling or disabling is specified by the operation input by the user, CPU 113 sets the value of the vibration flag within the memory 112 to “0” (disable) or “1” (enable) according to the specified content. Then, in the case of detecting operation input from the touch panel 102 or operation key 104a through 104c, the CPU 113 determines to perform or not perform vibration notification according to the value of the vibration flag.

[Alternate example 3]
For example, as shown in FIG. 78, the present invention can be applied in an operation panel 990 which is installed at a separate location from the lighting system main body, and is used for inputting operation instruction to the system main body. The operation panel 990 shown in the same drawing is installed on a wall surface in a room, for example. On the back surface of the operation panel 990, a vibration generator 991 such as the vibration actuator 115 is provided, for example. Furthermore, a control device that performs lighting system main body control, although not show in the drawing, performs vibration notification control including driving the vibration generator 991.

When an on/off key 992 on the operation panel 990 is switched by a fingertip of the user, the control device drives the vibration generator 991 and applies vibration to the fingertip of the user touching the on/off key 992. Furthermore, light intensity can be continuously changed between light and dark with the lighting system. When a slider switch 993 for instructing the control device for light intensity of the light is operated by a fingertip of the user, vibration greatness according to the light intensity of the lighting changed by the operation is applied to the fingertip of the user which is operating the slider switch 993. Note that instead of the slider switch 993, the configuration can use a dial type switch 994 shown in FIG. 79 or a plus key 995 and minus key 996 shown in FIG. 80 with similar functions as the slider switch 993.

Furthermore, as shown in FIG. 81, the present invention can be applied to an electronic device without a touch panel or displaying part such as a remote controller for a television or video. This electronic device may have a configuration that notifies the user that input from the operation key has been received by vibrating the operation key or housing.

[Alternate example 4]
In the first through twelfth embodiments, the direction of the vibration generated from the vibration generator such as the vibration actuator or vibrator is not restricted to the direction that is perpendicular to the surface of the touch panel or the pressing direction of the operation key. Furthermore, the frequency of a driving signal applied to the vibration actuator is not restricted to a frequency that resonates the housing of the electronic device or touch panel, the liquid crystal display panel equipped with the touch panel, or the actual vibration actuator. Similarly, the driving voltage applied to the vibrator is not restricted to a driving voltage that matches the rotational speed of the DC
motor to the natural frequency of the housing of the electronic device or touch panel, the liquid crystal display panel equipped with the touch panel, or the actual vibrator.

[Alternate example 5]

In the first through twelfth embodiments, the vibration generator is not restricted to a linear vibration actuator or a vibrator with eccentric weights. For example, a vibration generator or the like that uses piezoelectric element can be used.

Furthermore, in the embodiments except the second embodiment, a linear vibration actuator that uses a permanent magnet as a movable weight is described. Here, the requirements for the movable weight are proper mass required to generate vibration and the mechanism for the movable weight to achieve movement force for performing reciprocating motion. In the embodiments, a permanent magnet was used as a mechanism for achieving proper mass and movement force. However, the movable weight can be configured so that the permanent magnet is built in a part of the member as weight. Furthermore, the form may have the permanent magnet fixed in a case of the linear vibration actuator and a coil may be used as the movable weight. Furthermore, the form may have the coil fixed in the case and a different coil may be used as the movable weight. Of course, in this case, if the coil used as the movable weight does not have sufficient mass, the configuration may use the coil as a part of the weight with proper mass. Furthermore, the linear vibration actuator may be an iron core movable type linear vibration actuator.

Furthermore, the vibration actuator may be a so-called electrostatic vibration actuator that uses electrostatic force. Fig. 82 is a diagram for describing an electrostatic type vibration actuator according to the first alternate example of the present invention. In this diagram, the vibration actuator 800 has a movable weight 803 (weighted body) that has an electrode 802, and electrode 804 provided on the inside wall of the case 801, and a spring 805, provided in a case 801. Note that in the same drawing, the vibration subjected body is provided in a position facing the electrode 804 while interposing the case 801.

The movable weight 803 is a cylindrical weight, and the annular electrode 802 is provided on a bottom surface thereof. The movable weight 803 is supported in the space formed inside the case 801 by a spring 805 in a condition that can reciprocally move linearly in the vertical direction of the figure. As illustrated in the same drawing, one end of the spring 805 is connected to the case 801 (base member) that contacts with the liquid vibration subjected body, and the other end is connected to the movable weight 803. Note that the movable weight 803 without the electrode 802 maybe a weight having moderate mass. Furthermore, the annular electrode 804 is provided on a surface of an inner wall of the case 801 facing the electrode 802.

A plus or minus constant potential is always applied on the electrode 804, during driving of the vibration actuator 800 from the outside of the vibration actuator 800. On the other hand, an alternating voltage (drive signal) alternatingly swinging between plus and minus is applied on the electrode 802 of the movable weight 803 from the outside of the vibration actuator 800 through an amplifier 810.

Herein, if the potential of the electrode 802 and electrode 803 are mutually the same polarity, in other words, plus and plus or minus and minus, the movable weight 803 moves in the upward direction of the drawing due to the properties of electrostatic force where a charge of the same sign mutually repel. Herein, if the potential of the electrode 802 and electrode 803 have mutually different polarity, in other words, plus and minus, the movable weight 803 moves in the downward direction of the drawing due to the properties of electrostatic force where a charge of the different signs mutually attract.
For the vibration actuator 800 according to the present alternate example, the movable weight 803 performs linear reciprocal motion in the vertical direction of the drawing due to an electrostatic force. Furthermore, vibration acceleration is generated in a portion of the case 801 that is connected to the spring 805 as a reactive force to the reciprocal movement of the movable weight 803, and thus vibration is transmitted to the vibration subjected body. Note, in addition to the reactive force of the reciprocal motion, a vibration component that is transferred through the spring 805 from the movable weight 803 is also applied, in conjunction with the reciprocal movement of the movable weight 803 to the portion of the case 801 that is connected to the spring 805, but the basic principle of generating vibration in the vibration actuator 800 uses the vibration acceleration generated as the reactive force of the reciprocal movement of the movable weight 803, similarly to the vibration actuator 115 and the like described in the first embodiment.

Furthermore, FIG. 83 is a diagram for describing an electrostatic type vibration actuator according to the second example of the present alternate example. Even with the configuration illustrated in the same drawing, the movable weight 813 performs reciprocal motion due to an electrostatic force to generate vibrations, similarly to the vibration actuator 800 illustrated in FIG. 82. Furthermore, a vibration actuator 850 has total of two pairs of opposite electrodes, namely, an electrode 812a and electrode 814a and electrode 812b and electrode 814b, and if the condition is such that the first pair of opposite electrodes repel, the second pair of opposite electrodes will attract. Therefore, as compared to the vibration actuator 800 illustrated in FIG. 82, the electrostatic force that causes a reciprocal motion of the movable weight 813 doubles, and thus larger vibrations can be generated.

Note that the braking mechanism described in the first example and second example of the 13th embodiment may be further incorporated in the electrostatic type vibration actuators 800, 850 illustrated in FIG. 82 and FIG. 83. Furthermore, the waveform shape of the drive signal or electrode is not restricted to that which is illustrated in FIG. 82 and FIG. 83.

[Alternate example 6]

Furthermore, in the vibration actuator, the supporting member that reciprocally movably supports the movable weight in air is not restricted to a spring, string shaped rubber, and the like. For example, the supporting member may be a guide rail 967 as illustrated in FIG. 84. In the same drawing, a hole that penetrates a center portion in the vertical direction of the drawing is provided on the movable weight 963a. The guide rail 967 is provided so as to pass through the whole of the movable weight 963a, and one end thereof is secured to the case 961 that contacts the vibration subjected body. Even if the guide rail 967 is used, the movable weight 963a can be reciprocally movably supported in air by a magnetic force generated from the coil 962a. Furthermore, the guide rail 967 also has a role of restricting the motion direction of the movable weight 963a such that linear reciprocal motion is performed.

[Alternate example 7]

In the 1st through 12th embodiments, the operating part that vibrates due to the vibration generator is not restricted to a touch panel or operating key. For example, a keyboard itself having a plurality of operating keys, a mouse, a trackpad, tablet, and other various pointing devices may also be used. Furthermore, in optical coupling type, resistance type, contact type, magnetic coupling type, and other various types of touch panels can be used.
[Alternate example 8]

In the 1st embodiment through 12th embodiment, cases where the present invention was applied to a PDA or ATM were described. However, the present invention naturally can be applied to a mobile telephone, electronic notebook, mobile computer, watch, calculator, remote controller of an electronic apparatus, and other various mobile electronic apparatuses. Furthermore, the present invention can also be applied to various electronic apparatuses that do not have mobility, such as stationary computers, vending machines, cash registers, car navigation devices, home electric appliances, and the like.

Note that with electronic apparatuses that do not have mobility, a use form where a user grasps the electronic apparatus with one hand and performs operation input with another hand is difficult to foresee. Therefore, if a site other than the operating part is vibrated in the electronic apparatus, a portion of housing that the body of a user contacts or is assumed to contact during operation is preferably vibrated.

For example, FIG. 85 is a perspective view illustrating the appearance of an ATM 150 according to the present alternate example. In the same drawing, a liquid crystal display panel 153 on which a transparent touch panel 152 is overlaid is provided facing an opening part on a console 151 of the ATM 150. The user stands in front of the console 151 and performs touch operation on the touch panel 152. Note that a bill receiving and dispensing port 154 or coin receiving and dispensing port 155 is provided in addition to the touch panel 152 on the console 151. Furthermore, a passbook inserting port 156 or card inserting port 157 is provided on an upper front side surface of the ATM 150.

When a user performs touch operation on the ATM 150, the other hand that is different from the hand that is performing touch operation can be assumed to be placed on tabletop region 151a or tabletop region 151b. Therefore, a control part of the ATM 150 preferably drives the vibration generator omitted from the drawing based on detection of touch operation on the touch panel 152, and vibrates the tabletop region 151a or tabletop region 151b. Furthermore, when the user similarly performs touch operation, a portion of a thigh or torso of the user can be assumed to be in contact with table edge member 158 provided on a front of the console 151. Therefore, the control part of the ATM 150 preferably vibrates the table edge member 158 based on detection of touch operation on the touch panel 152.
Claims

1. An electronic apparatus, comprising:
   an operating part that receives an operation input;
   a vibration generator that provides vibration to a grasping part of the
electronic apparatus; and
   vibration controlling means that generates vibration from the vibration
generator when receipt of an operation input to the operating part is detected.

2. The electronic apparatus according to claim 1, the vibration generator comprising:
   a weighted body;
   a supporting member that supports in air the weighted body in a reciprocally
   movable manner, and is connected to the grasping part, or a base member of the
   vibration generator that is in contact with the grasping part; and
   motive force generating means that provides a motive force for causing
   reciprocal motion in the weighted body.

3. The electronic apparatus according to claim 1, wherein the vibration controlling
   means applies a drive signal that resonates the vibration generator or the grasping part
   to the vibration generator when driving the vibration generator to generate vibration.

4. The electronic apparatus according to claim 1, wherein the vibration
   generator is a motor where an eccentric weight is attached to a rotating shaft.

5. The electronic apparatus according to claim 4, wherein the vibration
   controlling means causes the rotational speed of the motor to match the vibrational
   frequency that causes the motor or the grasping part to resonate, when causing the
   motor to rotate to generate vibration.

6. The electronic apparatus according to claim 4 or 5, wherein the vibration
   controlling means stops rotation of the motor such that the eccentric weight stops at
   the same position when stopping rotation of the motor.

7. The electronic apparatus according to claim 1, further comprising specifying
   means for specifying whether or not to perform vibration notification based on the
   operation input;
   wherein the vibration controlling means causes generation of a vibration by
   the vibration generator based on detection of the operation input when the
   specifying means specifies to perform vibration notification.

8. An electronic apparatus, comprising:
   an operating part that receives an operation input;
   a vibration generator that provides vibration to the operating part; and
   vibration controlling means that generates vibration from the vibration
generator when receipt of an operation input to the operating part is detected;
   the vibration generator comprising:
   a weighted body;
   a supporting member that supports in air the weighted body in a reciprocally
   movable manner, and is connected to the operating part, or a base member of the
   vibration generator that is in contact with the operating part; and
motive force generating means that provides a motive force for causing reciprocal motion in the weighted body.

9. The electronic apparatus according to claim 8, wherein the vibration generator causes vibration of the operating part in the direction of contact with an operator and in the opposite direction thereof, when an operation is input to the operating part.

10. The electronic apparatus according to claim 8, wherein the vibration controlling means generates vibration from the vibration generator for a predetermined period of time of 1 second or less after receipt of an operation input to the operating part is detected.

11. The electronic apparatus according to claim 8 or 10, wherein the vibration controlling means applies a drive signal that resonates the vibration generator or the operating part to the vibration generator when driving the vibration generator to generate vibration.

12. The electronic apparatus according to any one of claims 8 through 11, wherein the operating part is a touch panel, and the vibration generator causes vibration of the touch panel or displaying means provided in the touch panel.

13. The electronic apparatus according to any one of claims 8 through 11, wherein the operating part has an operating element; and the vibration generator causes vibration of the operating elements.

14. The electronic apparatus according to claim 8, further comprising specifying means for specifying whether or not to perform vibration notification based on the operation input; wherein the vibration controlling means causes generation of a vibration by the vibration generator based on detection of the operation input when the specifying means specifies to perform vibration notification.

15. An electronic apparatus, comprising:
an operating part that receives an operation input;
a vibration generator that provides vibration to the operator; and vibration controlling means that generates vibration from the vibration generator when execution of the process specified by the operation input to the operating part is completed.

16. The electronic apparatus according to claim 15, wherein the vibration controlling means switches the vibration form of the vibration generator based on the process execution results.

17. The electronic apparatus according to claim 15 or 16, wherein the vibration generator provides vibration to the operating part or the grasping part of the electronic apparatus.

18. The electronic apparatus according to claim 15 or 16, wherein the vibration generator provides vibration to the operating part; the vibration generator comprising:
a weighted body;
a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the operating part, or a base member of the vibration generator that is in contact with the operating part; and
motive force generating means that provides a motive force for causing reciprocal motion in the weighted body.

19. The electronic apparatus according to claim 15 or 16, wherein the vibration generator provides vibration to the grasping part of the electronic apparatus; the vibration generator comprising:
a weighted body;
a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the grasping part, or a base member of the vibration generator that is in contact with the grasping part; and
motive force generating means that provides a motive force for causing reciprocal motion in the weighted body.

20. The electronic apparatus according to claim 15 or 16, wherein the vibration generator provides vibration to the operating part or the grasping part of the electronic apparatus, wherein
the vibration controlling means applies a drive signal that resonates one of the vibration generator, operating part, or grasping part, to the vibration generator when driving the vibration generator to generate vibration.

21. An electronic apparatus, comprising:
an operating part that receives an operation input;
a first vibration generator that provides vibration to the operating part; and
a vibration generator that provides vibration to a grasping part of the electronic apparatus; and
vibration controlling means that generates vibration from at least one of the first vibration generator and the second vibration generator as specified beforehand by the operator, when receipt of an operation input to the operating part is detected.

22. An electronic apparatus, comprising:
an operating part that receives an operation input;
a first vibration generator that provides vibration to the operating part; and
a vibration generator that provides vibration to a grasping part of the electronic apparatus;
detecting means that detects if the electronic apparatus is held by an operator; and
vibration controlling means that selects at least one of the first vibration generator and the second vibration generator based on the detection results of the detecting means, and causes vibration of the selected vibration generator, when receipt of an operation input to the operating part is detected.

23. The electronic apparatus according to claim 22, wherein the vibration controlling means causes generation of vibration from the first vibration generator when receipt of an operation input to the operating part is detected, and the detecting means detects that an operator is not grasping the electronic apparatus.

24. The electronic apparatus according to claim 1, the first vibration generator comprising:
a weighted body;
a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the operating part, or a base member of the vibration generator that is in contact with the operating part; and motive force generating means that provides a motive force for causing reciprocal motion in the weighted body.

25. The electronic apparatus according to claim 21 or 22, the first vibration generator comprising:

26. The electronic apparatus according to any one of claims 8, 18, and 24, wherein the vibration generator causes the weighted body to reciprocally move by the motive force generated by the motive force generating means, causes vibration acceleration of the operating part as a reaction to the reciprocal motion, or provides the vibration acceleration generated in the base member as a reaction to the reciprocal motion, to the operating part.

27. The electronic apparatus according to any one of claims 2, 19, and 25, wherein the vibration generator causes the weighted body to reciprocally move by the motive force generated by the motive force generating means, causes vibration acceleration of the grasping part as a reaction to the reciprocal motion, or provides the vibration acceleration generated in the base member as a reaction to the reciprocal motion, to the grasping part.

28. The electronic apparatus according to any one of claims 8, 18, and 24, wherein the supporting member is made of an elastic body, one end of which is connected to the operating part or the base member, and the other end is connected to the weighted body.

29. The electronic apparatus according to any one of claims 2, 19, and 25, wherein the supporting member is made of an elastic body, one end of which is connected to the operating part or the base member, and the other end is connected to the weighted body.

30. The electronic apparatus according to any one of claims 2, 8, 18, 19, 24, and 25, the vibration generator further comprising a guiding mechanism for the weighted body in order to cause linear reciprocal motion of the weighted body.

31. The electronic apparatus according to any one of claims 2, 8, 18, 19, 24, and 25, wherein the motive force generating means causes generation of a magnetic force as the motive force.

32. The electronic apparatus according to any one of claims 2, 8, 18, 19, 24, and 25, wherein the motive force generating means causes generation of an electrostatic force as the motive force.
33. The electronic apparatus according to any one of claims 2, 8, 18, 19, 24, 25, and 30, the vibration generator causes linear reciprocal motion of the weighted body, and further comprises a resistance providing member that provides contact resistance to the weighted body by always contacting with site surface of the reciprocally moving weighted body in a direction parallel to the direction of reciprocal motion.

34. The electronic apparatus according to any one of claims 2, 8, 18, 19, 24, 25, and 30, further comprising braking means that stops the reciprocal motion of the weighted body by contacting with the weighted body, when generation of the motive force by the motive force generating means is stopped.

35. The electronic apparatus according to any one of claims 2, 8, 18, 19, 24, 25, and 30, comprising:
   a coil that causes generation of a magnetic force as the motive force generating means;
   the electronic apparatus further comprising:
   shorting means that shorts the input terminal of the coil when the supply of current to the coil is stopped.

36. The electronic apparatus according to any one of claims 2, 8, 18, 19, 24, and 25, wherein the motive force generating means causes generation of a magnetic force as the motive force; and
   the vibration generator stores the weighted body, the supporting member, and the motive force generating means in a sealed space in a case with a magnetic shielding effect.

37. The electronic apparatus according to any one of claims 2, 8, 18, 19, 24, and 25, wherein the motive force generating means causes generation of a magnetic force as the motive force; and
   the weighted body is configured using a permanent magnet.

38. An electronic apparatus, comprising:
   a display panel with a touch panel overlaid thereon;
   a vibration generator provided in the display panel;
   an elastic member configured using an elastic body, that supports the display panel in a manner that can vibrate by the vibration generated from the vibration generator; and
   vibration controlling means that causes generation of vibration from the vibration generator when receipt of a touch operation to the touch panel is detected;
   the vibration generator comprising:
   a weighted body;
   a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the display panel or a base member of the vibration generator that is in contact with the display panel; and motive force generating means that provides a motive force for causing reciprocal motion to the weighted body.

39. The electronic apparatus according to claim 38, wherein the display panel is attached to the housing of the electronic apparatus through the elastic member.
40. The electronic apparatus according to claim 38, wherein the display panel is attached to the main body device of the electronic apparatus through the elastic member.

41. An electronic apparatus, comprising:
   a display panel with a touch panel overlaid thereon;
   a vibration generator that provides vibration to the display panel and supports the display panel;
   vibration controlling means that causes generation of vibration from the vibration generator when receipt of a touch operation to the touch panel is detected;
   the vibration generator comprising:
      a weighted body;
      a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the display panel or a base member of the vibration generator that is in contact with the display panel; and motive force generating means that provides a motive force for causing reciprocal motion to the weighted body.

42. The electronic apparatus according to claim 41, wherein the display panel is attached to the housing of the electronic apparatus through the vibration generator.

43. The electronic apparatus according to claim 41, wherein the display panel is attached to the main body device of the electronic apparatus through the vibration generator.

44. The electronic apparatus according to any one of claims 38 and 41, wherein the vibration generator causes the weighted body to reciprocally move by the motive force generated by the motive force generating means, causes vibration acceleration of the display panel as a reaction to the reciprocal motion, or provides the vibration acceleration generated in the base member as a reaction to the reciprocal motion, to the display panel.

45. The electronic apparatus according to any one of claims 38 and 41, wherein the supporting member is configured using an elastic body, one end of which is connected to the display panel or the base member, and the other end is connected to the weighted body.

46. The electronic apparatus according to claim 38 or 41, wherein the vibration generator provides vibration to the display panel in a direction that is perpendicular to the surface of the display panel.

47. The electronic apparatus according to claim 38 or 41, wherein the vibration controlling means causes generation of vibration from the vibration generator for a predetermined period of time of 1 second or less after receipt of a touch operation to the touch panel is detected.

48. The electronic apparatus according to any one of claims 38, 41, and 47, wherein the vibration controlling means applies a drive signal that causes resonance of the vibration generator or the display panel to the vibration generator, when driving the vibration generator to generate vibration.

49. An electronic apparatus, comprising:
a touch panel that covers the display surface of the display;
a vibration generator provided between the display and the touch panel, that supports the touch panel on the display screen, and that provides vibration to the display panel;
vibration controlling means that causes generation of vibration from the vibration generator when receipt of a touch operation to the touch panel is detected.

50. An electronic apparatus, comprising:
a display;
a touch panel that covers the display surface of the display;
a vibration generator that provides vibration to the touch panel and is installed on the touch panel;
a vibration absorbing member provided between the display and the touch panel, that absorbs the vibrational component that is transferred to the display, of the vibration generated by the vibration generator; and
vibration controlling means that causes generation of vibration from the vibration generator when receipt of a touch operation to the touch panel is detected.

51. The electronic apparatus according to claims 49 or 50, the vibration generator comprising:
a weighted body;
a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the touch panel, or a base member of the vibration generator that is in contact with the touch panel; and
motive force generating means that provides a motive force for causing reciprocal motion in the weighted body.

52. The electronic apparatus according to claims 38 or 41, wherein the vibration generator causes the weighted body to reciprocally move by the motive force generated by the motive force generating means, causes vibration acceleration of the touch panel as a reaction to the reciprocal motion, or provides the vibration acceleration generated in the base member as a reaction to the reciprocal motion, to the touch panel.

53. The electronic apparatus according to claim 51, wherein the supporting member is configured using an elastic body, one end of which is connected to the touch panel or the base member, and the other end is connected to the weighted body.

54. The electronic apparatus according to claim 50, wherein an elastic body is used for the vibration absorbing member.

55. The electronic apparatus according to claim 50 or 54, wherein the vibration absorbing member is provided at a position that does not overlay the display screen.

56. The electronic apparatus according to claim 49 or 50, wherein the vibration generator is provided at a position that does not overlay the display screen.

57. The electronic apparatus according to any one of claims 49 through 52 and 56, wherein the vibration generator closes vibration to the touch panel in a direction that is perpendicular to the surface of the touch panel.
58. The electronic apparatus according to claim 49 or 50, wherein the vibration controlling means causes generation of vibration from the vibration generator for a predetermined period of time of 1 second or less after receipt of a touch operation to the touch panel is detected.

59. The electronic apparatus according to any one of claims 38, 41, and 47 wherein the vibration controlling means applies a drive signal that causes resonance of the vibration generator or the touch panel to the vibration generator, when driving the vibration generator to generate vibration.

60. An electronic apparatus, comprising:
   an operating part that receives an operation input;
   a vibration generator provided such that at least a portion is exposed to the outside from the housing of the electronic apparatus, and that provides direct vibration to an operator;
   vibration controlling means that generates vibration from the vibration generator when receipt of an operation input to the operating part is detected.

61. An electronic apparatus, comprising:
   an operating part that receives an operation input;
   a vibration generator that provides vibration to a portion of the housing of the electronic apparatus that is different from the operating part; and
   vibration controlling means that specifies the type of operation input, and causes generation of vibration from the vibration generator in a vibration form that corresponds to the type of operation input, when receipt of an operation input to the operating part is detected.

62. The electronic apparatus according to claim 61, wherein
   the operating part is a touch panel, and
   the vibration controlling means detects the touch position of the touch operation to the touch panel, and causes generation of vibration from the vibration generator in a vibration form that corresponds to the touch position, after receipt of a touch operation to the touch panel is detected.

63. The electronic apparatus according to claim 61, wherein
   the operating part has a plurality operating element; and
   the vibration controlling means specifies the type of operating element that is operated, and causes generation of vibration from the vibration generator in a vibration form that corresponds to the type of operating element, when receipt of an operation input to the operating part is detected.

64. The electronic apparatus according to claim 61, wherein the vibration controlling means specifies the type of command indicating the operation input, and causes generation of vibration from the vibration generator in a vibration form that corresponds to the type of command, when receipt of an operation input to the operating part is detected.

65. An electronic apparatus, comprising:
   an operating part that receives an operation input;
a vibration generator that provides vibration to a portion of the housing of
the electronic apparatus that is different from the operating part; and changing
means that changes a parameter value for controlling the electronic apparatus based
on the operation input to the operating part; and
vibration controlling means that causes generation of vibration from the
vibration generator in a vibration form that corresponds to the parameter value that
was changed by the changing means based on the operation input, when receipt of
an operation input to the operating part is detected.

66. The electronic apparatus according to claims 61 or 65, the vibration
generator comprising:
   a weighted body;
   a supporting member that supports in air the weighted body in a reciprocally
   movable manner, and is connected to a portion of the housing or a base member of
   the vibration generator that is in contact with a portion of the housing; and motive
   force generating means that provides a motive force for causing reciprocal motion to
   the weighted body.

67. The electronic apparatus according to claim 66, wherein
   the vibration generator causes the weighted body to reciprocally move by the
   motive force generated by the motive force generating means, causes vibration
   acceleration of a portion of the housing as a reaction to the reciprocal motion, or
   provides the vibration acceleration generated in the base member as a reaction to the
   reciprocal motion, to a portion of the housing.

68. The electronic apparatus according to claim 66, wherein the supporting member is
   configured using an elastic body, one end of which is connected to a portion of the
   housing or the base member, and the other end is connected to the weighted body.

69. The electronic apparatus according to any one of claims 61 through 65,
   wherein the vibration controlling means applies a drive signal that causes resonance
   of the vibration generator or a portion of the housing to the vibration generator,
   when driving the vibration generator to generate vibration.

70. An electronic apparatus, comprising:
   an operating part that receives an operation input;
   a vibration generator that provides vibration to the operating part; and
   vibration controlling means that specifies the type of operation input, and
   causes generation of vibration from the vibration generator in a vibration form that
   corresponds to the type of operation input, when receipt of an operation input to the
   operating part is detected.
   the vibration generator comprising:
   a weighted body;
   a supporting member that supports in air the weighted body in a reciprocally
   movable manner, and is connected to the operating part, or a base member of the
   vibration generator that is in contact with the operating part; and
   motive force generating means that provides a motive force for causing
   reciprocal motion in the weighted body.

71. The electronic apparatus according to claim 61, wherein
the operating part is a touch panel, and the vibration controlling means detects the touch position of the touch operation to the touch panel, and causes generation of vibration from the vibration generator in a vibration form that corresponds to the touch position, after receipt of a touch operation to the touch panel is detected.

72. The electronic apparatus according to claim 70, wherein the operating part has a plurality operating element; and the vibration controlling means specifies the type of operating element that is operated, and causes generation of vibration from the vibration generator in a vibration form that corresponds to the type of operating element, when receipt of an operation input to the operating part is detected.

73. The electronic apparatus according to claim 70, wherein the vibration controlling means specifies the type of command indicating the operation input, and causes generation of vibration from the vibration generator in a vibration form that corresponds to the type of command, when receipt of an operation input to the operating part is detected.

74. An electronic apparatus, comprising:
an operating part that receives an operation input;
a vibration generator that provides vibration to the operating part; and changing means that changes a parameter value for controlling the electronic apparatus based on the operation input to the operating part; and vibration controlling means that causes generation of vibration from the vibration generator in a vibration form that corresponds to the parameter value that was changed by the changing means based on the operation input, when receipt of an operation input to the operating part is detected.

the vibration generator comprising:
a weighted body;
a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the operating part, or a base member of the vibration generator that is in contact with the operating part; and motive force generating means that provides a motive force for causing reciprocal motion in the weighted body.

75. The electronic apparatus according to claim 70 or 74, wherein the vibration generator causes the weighted body to reciprocally move by the motive force generated by the motive force generating means, causes vibration acceleration of the operating part as a reaction to the reciprocal motion, or provides the vibration acceleration generated in the base member as a reaction to the reciprocal motion, to the operating part.

76. The electronic apparatus according to any one of claims 70 and 74, wherein the supporting member is configured using an elastic body, one end of which is connected to the operating part or the base member, and the other end is connected to the weighted part.

77. The electronic apparatus according to any one of claims 70 through 74, wherein the vibration generator causes vibration of the operating part in the
direction of contact with an operator and in the opposite direction thereof, when an
operation is input to the operating part.

78. The electronic apparatus according to any one of claims 70 through 74,
wherein the vibration controlling means generates vibration from the vibration
generator for a predetermined period of time of one second or less after receipt of an
operation input to the operating part is detected.

79. The electronic apparatus according to any one of claims 70 through 74 and
78, wherein the vibration controlling means applies a drive signal that causes
resonance of the vibration generator or the operating part to the vibration generator,
when driving the vibration generator to generate vibration.

80. An electronic device, comprising:
an operating element that continuously changes a parameter value for
controlling the electronic apparatus;
a vibration generator that provides vibration to the operator; and
changing means for changing the parameter value based on the level of
operation of the operating element;
vibration controlling means that causes generation of vibration from the
vibration generator in a vibration form that corresponds to the parameter value that
was changed by the changing means based on the operation, when receipt of an
operation of the operating element is detected.

81. An electronic apparatus, comprising:
an operating part that receives an operation input, and detects the level of
pressing of the operation input;
a vibration generator that provides vibration to the operator; and
vibration controlling means that causes generation of vibration from the
vibration generator in a vibration form that corresponds to the pressing level of the
operation input that was detected by the operating part, when receipt of an operation
input to the operating part is detected.

82. The electronic apparatus according to claim 81, wherein the operating part
detects that a fingertip of an operator or an operating tool has contacted the
operating part, and detects different pressing levels that the fingertip or the
operating tool presses on the operating part above a predetermined pressing level.

83. The electronic apparatus according to claim 81 or 82, wherein the operating
part is a touch panel.

84. The electronic apparatus according to claim 81, the operating part comprising:
a first touch panel that detects that a fingertip of the operator or an operating tool has contacted the
operating part and receives this as a touch operation; and a second touch
panel that detects that a fingertip of an operator or an operating tool has contacted the
operating part with a force that is above a predetermined pressing level, and received
this as a touch operation; overlaid together.

85. An electronic apparatus, comprising:
an operating part that receives an operation input;
sound generating means that provides a notification sound to the operator; a vibration generator that provides vibration to the operator; and notification controlling means that notifies the operator that an operation input has been received using one or more of the sound generating means and the vibration generator, specified beforehand by the operator, when receipt of an operation input to the operating part is detected.

86. An electronic apparatus, comprising:
   an operating part that receives an operation input;
   sound generating means that provides a notification sound to the operator;
   a vibration generator that provides vibration to the operator; and
   measuring means that measures the volume of sound around the electronic apparatus; and
   notification controlling means that selects one or more of the sound generating means and the vibration generator based on the measurement results of the measuring means, and notifies the operator that an operation input has been received using the selected means, when receipt of an operation input to the operating part is detected.

87. The electronic apparatus according to claim 86, wherein the notification controlling means notifies the operator that an operation input has been received using at least the vibration generator, when the volume of noise measured by the measuring means is above a volume set beforehand, when receipt of an operation input to the operating part is detected.

88. An electronic apparatus, comprising:
   an operating part that receives an operation input;
   sound generating means that provides a notification sound to the operator;
   a vibration generator that provides vibration to the operator; and
   receiving means that receives a signal specifying at least one of the sound generating means or the vibration generator from a base station that covers an area where the electronic apparatus exists; and
   notification controlling means that notifies the operator that an operation input has been received using one or more of the sound generating means and the vibration generator, specified by the signal received from the receiving means, when receipt of an operation input to the operating part is detected.

89. An electronic apparatus, comprising:
   an operating part that receives an operation input;
   sound generating means that provides a notification sound to the operator;
   a vibration generator that provides vibration to the operator; and
   acquiring means that acquires positional information for the electronic apparatus; and
   notification controlling means that selects one or more of the sound generating means and the vibration generator based on positional information acquired by the acquiring means, and notifies the operator that an operation input has been received using the selected means, when receipt of an operation input to the operating part is detected.

90. The electronic apparatus according to claim 89, wherein the notification controlling means notifies the operator that an operation input has been received using at least the vibration generator, when the electronic apparatus is located in a
preestablished area, based on the positional information acquired by the acquiring means, when receipt of an operation input to the operating part is detected.

91. An electronic apparatus, comprising:
   an operating part that receives an operation input;
   a vibration generator that can cause generation of noise at the same time as providing vibration to an operator; and
   drive controlling means that synthesizes a drive signal for causing generation of vibration and driving the vibration generator, and an audio signal for causing generation of a sound by driving the vibration generator, and applying the synthesized signals to the vibration generator, when causing generation of sound and vibration from the vibration generator, when receipt of an operation input to the operating part is detected.

92. The electronic apparatus according to any one of claims 80, 81, 85, 86, 88, 89, and 91, wherein the vibration generator provides vibration to the operator by causing vibration to any member that comprises the electronic apparatus; the vibration generator comprising:
   a weighted body;
   a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to a vibration subjected member of the electronic apparatus or a base member of the vibration generator that is in contact with a vibration subjected member; and
   motive force generating means that provides a motive force for causing reciprocal motion in the weighted body.

93. The electronic apparatus according to claim 92, wherein
   the vibration generator causes the weighted body to reciprocally move by the motive force generated by the motive force generating means, causes vibration acceleration of the vibration subjected member as a reaction to the reciprocal motion, or provides the vibration acceleration generated in the base member as a reaction to the reciprocal motion, to the vibration subjected member.

94. The electronic apparatus according to claim 92, wherein the supporting member is configured using an elastic body, one end of which is connected to a portion of the vibration subjected member or the base member, and the other end is connected to the weighted body.

95. An electronic apparatus, comprising:
   an operating panel that receives a touch operation;
   a plurality of vibration generators that provide vibration to the operating panel; detecting means that detects the touch position on the operating panel;
   vibration controlling means that selects one or more of the plurality of vibration generators based on the touch position of the touch operation that was detected by the detecting means, and causes generation of vibration from the vibration generator that was selected, when receipt of a touch operation to the touch panel is detected.

96. An electronic apparatus, comprising:
   an operating panel that receives a touch operation;
   a plurality of vibration generators that provide vibration to the operating panel; detecting means that detects the touch position on the operating panel;
generating means that reproduces a drive signal that drives each of the plurality of vibration generators so as to amplify the amplitude of the vibration generated at the touch position of the touch operation that was detected by the detecting means, by mutual interference of the vibration waves generated from each of the plurality of vibration generators, when receipt of a touch operation to the touch panel is detected; and

vibration controlling means that applies each of the drive signals reproduced by the generating means to the corresponding vibration generator, and reproduces the vibration from each of the vibration generators.

97. The electronic apparatus according to claim 96, wherein the generating means adjusts the phase of the drive signal that drives each of the plurality of vibration generators so as to amplify the amplitude of the vibration generated at the touch position of the touch operation that was detected by the detecting means, by mutual interference of the vibration waves generated from each of the plurality of vibration generators, when receipt of a touch operation to the touch panel is detected.

98. The electronic apparatus according to claim 96, wherein the generating means reproduces the drive signal that drives each of the plurality of vibration generators so as to maximize the amplitude of the vibration generated at the touch position of the touch operation that was detected by the detecting means, by mutual interference of the vibration waves generated from each of the plurality of vibration generators, when receipt of a touch operation to the touch panel is detected.

99. An electronic apparatus, comprising:
- an operating panel where a deformation layer that can deform by vibration is laminated;
- a plurality of vibration generators that provide vibration to the operating panel;
- detecting means that detects the touch position on the operating panel;
- generating means that reproduces a drive signal that drives each of the plurality of vibration generators so as to make the layer thickness of the deformation layer to be thicker or thinner compared to when not touched, at the touch position of the touch operation that was detected by the detecting means, by mutual interference of the vibration waves generated from each of the plurality of vibration generators, when receipt of a touch operation to the touch panel is detected; and
- vibration controlling means that applies each of the drive signals reproduced by the generating means to the corresponding vibration generator, and reproduces the vibration from each of the vibration generators.

100. The electronic apparatus according to claim 99, wherein the deformation layer is configured using any liquid, gel, or powder substance.

101. The electronic apparatus according to any one of claims 95, 96, and 99, the vibration generator comprising:
- a weighted body;
- a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to the operating panel or a base member of the vibration generator that is in contact with the operating panel; and
- motive force generating means that provides a motive force for causing reciprocal motion to the weighted body.
102. The electronic apparatus according to claim 101, wherein
the vibration generator causes the weighted body to reciprocally move by the
motive force generated by the motive force generating means, causes vibration
acceleration of the operating panel as a reaction to the reciprocal motion, or
provides the vibration acceleration generated in the base member as a reaction to the
reciprocal motion, to the operating panel.

103. The electronic apparatus according to claim 101, wherein the supporting member
is configured using an elastic body, one end of which is connected to the operating panel
or the base member, and the other end is connected to the weighted part.

104. The electronic apparatus according to any one of claims 38, 41, 51, 66, 70,
74, 92, and 101, the vibration generator further comprising a guiding mechanism for
the weighted body in order to cause linear reciprocal motion of the weighted body.

105. The electronic apparatus according to any one of claims 38, 41, 51, 66, 70,
74, 92, and 101, wherein in the motive force generating means causes generation of a
magnetic force as the motive force.

106. The electronic apparatus according to any one of claims 38, 41, 51, 66, 70,
74, 92, and 101, wherein the motive force generating means causes generation of an
electrostatic force as the motive force.

107. The electronic apparatus according to any one of claims 38, 41, 51, 66, 70,
74, 92, and 101, the vibration generator causes linear reciprocal motion of the weighted body,
and further comprises a resistance providing member that provides contact resistance to
the weighted body by always contacting with site surface of the reciprocally moving
weighted body in a direction parallel to the direction of reciprocal motion.

108. The electronic apparatus according to any one of claims 38, 41, 51, 66, 70,
74, 92, and 101, the vibration generator further comprising braking means that stops the reciprocal motion of the
weighted body by contacting with the weighted body, when generation of the
motive force by the motive force generating means is stopped.

109. The electronic apparatus according to any one of claims 38, 41, 51, 66, 70,
74, 92, and 101, the vibration generator further comprising:

   a coil that causes generation of a magnetic force as the motive force
generating means;
   the electronic apparatus further comprising:
   shorting means that shorts the input terminal of the coil when the supply of
current to the coil is stopped.

110. The electronic apparatus according to any one of claims 38, 41, 51, 66, 70,
74, 92, and 101, wherein the motive force generating means causes generation of a
magnetic force as the motive force; and
the vibration generator stores the weighted body, the supporting member, and
the motive force generating means in a sealed space in a case with a magnetic
shielding effect.
111. The electronic apparatus according to any one of claims 38, 41, 51, 66, 70, 74, 92, and 101, wherein the motive force generating means causes generation of a magnetic force as the motive force; and
the weighted body is configured using a permanent magnet.

112. A vibration generator, comprising:
   a weighted body;
   a supporting member that supports in air the weighted body in a linear reciprocally movable manner, and is connected to a vibration subjected member is provided vibration by the vibration generator or a base member of the vibration generator that is in contact with a vibration subjected member; and
   motive force generating means that provides a motive force for causing reciprocal motion to the weighted body; and
   a resistance providing member that always contacts a side surface that runs parallel to the direction of reciprocal motion of the weighted body that performs linear reciprocal motion due to the motive force generated by the motive force generating means, and provides contact resistance to the weighted body.

113. The vibration generator according to claim 112, wherein the resistance providing member encircles the entire side surface that runs parallel to the direction of reciprocal motion of the weighted body.

114. The vibration generator according to claim 112, wherein a plurality of resistance providing member are provided at equivalent intervals so as to encircle the entire side surface that runs parallel to the direction of reciprocal motion of the weighted body.

115. A vibration generator, comprising:
   a weighted body;
   a supporting member that supports in air the weighted body in a reciprocally movable manner, and is connected to a vibration subjected member is provided vibration by the vibration generator or a base member of the vibration generator that is in contact with a vibration subjected member; and
   motive force generating means that provides a motive force for causing reciprocal motion to the weighted body; and
   braking means that stops the reciprocal motion of the weighted body by contacting with the weighted body, when generation of the motive force by the motive force generating means is stopped.

116. The electronic apparatus according to claim 115, the vibration generator further comprising a guiding mechanism for the weighted body in order to cause linear reciprocal motion of the weighted body.

117. The vibration generator according to claim 112 or 115, that causes the weighted body to reciprocally move by the motive force generated by the motive force generating means, causes vibration acceleration of the vibration subjected body as a reaction to the reciprocal motion, or provides the vibration acceleration generated in the base member as a reaction to the reciprocal motion, to the vibration subjected body.

118. The vibration generator according to claim 112 or 115, wherein the supporting member is configured using an elastic body, one end of which is
connected to the vibration subjected body or the base member, and the other end is connected to the weighted part.

119. The electronic apparatus according to claim 112 or 115, wherein the motive force generating means causes generation of a magnetic force as the motive force.

120. The electronic apparatus according to claim 112 or 115, wherein the motive force generating means causes generation of an electrostatic force as the motive force.

121. The electronic apparatus according to claim 112 or 115, wherein the motive force generating means causes generation of a magnetic force as the motive force; and the weighted body is configured using a permanent magnet.

122. A method of notifying by vibration in an electronic apparatus, comprising: causing vibration of a grasping part of the electronic apparatus by causing generation of vibration from a vibration generator contained in the electronic apparatus, when receipt of an operation input to the operating part is detected.

123. A method of notifying by vibration in an electronic apparatus, comprising: driving a vibration generator contained in the electronic apparatus, and causing vibration of the operating part by causing reciprocal motion in a weighted body supported in air in a reciprocally movable manner by a supporting member that is connected to the operating part or a base member of the vibration generator that is in contact with the operating part.

124. A method of notifying by vibration in an electronic apparatus, comprising: providing vibration to an operator by causing generation of vibration from the vibration generator provided in the electronic apparatus, when execution of the process specified by the operation input to the operating part is completed.

125. A method of notifying by vibration in an electronic apparatus, comprising: providing vibration to an operator by causing generation of vibration from at least one of a first vibration generator that provides vibration to the operating part and a second vibration generator that provides vibration to the grasping part of the electronic apparatus, as specified beforehand by the operator, when receipt of an operation input to the operating part is detected.

126. A method of notifying by vibration in an electronic apparatus, comprising: selecting one or more of the first vibration generator that provides vibration to the operating part, provided in the electronic apparatus, and a second vibration generator that provides vibration to the grasping part of the electronic apparatus, based on detection results of a sensor that detects whether or not the electronic apparatus is being grasped by an operator, and provides vibration to the operator by causing generation of vibration from the selected vibration generator, when receipt of an operation input to the operating part is detected.

127. A method of notifying by vibration in an electronic apparatus, comprising: specifying the type of operation input, and causing generation of vibration of vibration from a vibration generator provided in the electronic apparatus, in a vibration form corresponding to the type of operation input, and causing vibration to
a portion of the housing of the electronic apparatus that is different from the operating part, when receipt of an operation input to the operating part is detected.

128. A method of notifying by vibration in an electronic apparatus, comprising: specifying the type of operation input, driving a vibration generator contained in the electronic apparatus, and causing vibration of the operating part by causing reciprocal motion in a weighted body supported in air in a reciprocally movable manner by a supporting member that is connected to the operating part or a base member of the vibration generator that is in contact with the operating part.

129. A method of notifying by vibration in an electronic apparatus, comprising: synthesizing a drive signal for causing generation of vibration and driving the vibration generator, and an audio signal for causing generation of a sound by driving the vibration generator, and generating sound at the same time as providing vibration to the operator by driving the vibration generator using the synthesized signal, when causing generation of sound and vibration from the vibration generator provided in the electronic apparatus, when receipt of an operation input to the operating part is detected.

130. A method of notifying by vibration in an electronic apparatus, comprising: detecting a touch position when receipt of a touch operation to the touch panel is detected, selecting one or more of the plurality of vibration generators provided in the electronic apparatus, based on the touch position, and providing vibration to the operator by causing generation of vibration from the vibration generator that was selected.

131. A method of notifying by vibration in an electronic apparatus, comprising: detecting a touch position when receipt of a touch operation to the touch panel is detected, driving each of the vibration generators by generating a drive signal that is applied to each of the plurality of vibration generators so as to amplify the amplitude of the vibration generated at the touch position on the touch panel, by mutual interference of the vibration waves generated from each of the plurality of vibration generators, and providing vibration to the operator.

132. A method of controlling notification in an electronic apparatus, comprising: notifying the operator that an operation input has been received using one or more of the sound generating means and the vibration generator provided in the electronic apparatus, specified beforehand by the operator, when receipt of an operation input to the operating part is detected.

133. A method of controlling notification in an electronic apparatus, comprising: selecting one or more of the sound generating means and the vibration generator that provides vibration to the operator, provided in the electronic apparatus, based on the measurement results of the measuring device that measures the noise volume around the electronic apparatus, and notifying the operator that an operation input has been received, using the selected means, when receipt of an operation input to the operating part is detected.

134. A method of controlling notification in an electronic apparatus, comprising: notifying the operator that an operation input has been received using one or more of the sound generating means that provides a notification sound to the operator, and a vibration generator that provides vibration to the operator, specified
by the signal received from a base station that covers the area where the electronic apparatus exists, when receipt of an operation input to the operating part is detected.

135. A method of controlling notification in an electronic apparatus, comprising: selecting one or more of the sound generating means and the vibration generator that provides vibration to the operator, provided in the electronic apparatus, based on the positional information of the electronic apparatus, and notifying the operator that an operation input has been received, using the selected means, when receipt of an operation input to the operating part is detected.
FIG. 5

Vibration control process 1

Operation input detected?

Yes

Read waveform data

S102

Instruct to generate drive signal

S103

Reset count value

S104

Instruct to start applying drive signal

S105

Start timing

S106

Count up

S107

Is applied time < specified time?

S108

No

Instruct to stop applying

S109

Yes

END
FIG. 11

Vibration control process 2

Operation input detected?

Yes

Read waveform data

Instruct to generate drive signal

Reset count value

Instruct to start applying drive signal

Start timing

Count up

Is applied time < specified time?

Yes

No

Decide timing to stop applying

Instruct to stop applying

END
FIG. 14

Vibration control process 3

S301
Performed process that was instructed

S302
Completed?

S303
Read waveform data

S304
Instruct to generate drive signal

S305
Reset count value

S306
Instruct to start applying drive signal

S307
Start timing

S308
Count up

S309
Is applied time < specified time?

S310
Instruct to stop applying

END
FIG. 15

Vibration control process 4

- Performed process that was instructed

Completed?

Yes

Acquire execution results

Change specified timing based on execution results

Read waveform data

Instruct to generate drive signal

Reset count value

Instruct to start applying drive signal

S401

S402

S403

S404

S405

S406

S407

S408

Start timing

Count up

Is applied time > specified time?

No

Yes

Instruct to stop applying

END

S409

S410

S411

S412
FIG. 27
FIG. 29

Display screen region

50a 504

115a

502

501

115b

504

53
FIG. 32

![Diagram showing a grid with buttons labeled A to G and a reference number 102.]

FIG. 33

<table>
<thead>
<tr>
<th>Touch button</th>
<th>Area data</th>
<th>Waveform data</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>Operation command</td>
<td>Waveform data</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------</td>
<td></td>
</tr>
<tr>
<td>Decide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Click</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drag</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select icon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delete data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open file</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power off</td>
<td></td>
<td></td>
</tr>
<tr>
<td>:</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>:</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>:</td>
<td>:</td>
<td></td>
</tr>
</tbody>
</table>
FIG. 41

FIG. 42

<table>
<thead>
<tr>
<th>Parameter value</th>
<th>Waveform data</th>
</tr>
</thead>
<tbody>
<tr>
<td>0~25</td>
<td></td>
</tr>
<tr>
<td>26~50</td>
<td></td>
</tr>
<tr>
<td>51~75</td>
<td></td>
</tr>
<tr>
<td>76~100</td>
<td></td>
</tr>
</tbody>
</table>
### FIG. 45

\[ \text{Diagram of a waveform with } f_0 \]

### FIG. 46

<table>
<thead>
<tr>
<th>Touch button</th>
<th>Area data</th>
<th>Waveform data</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>Touch operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressing operation</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>Touch operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressing operation</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>Touch operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressing operation</td>
</tr>
</tbody>
</table>

112d
FIG. 47

CPU 113

102 Touch panel

111 Key input part

112 Memory

103 Display part

114 Drive signal generating circuit

115 Vibration actuator

602 Sound volume measuring circuit

603 Beep sound generating circuit

601

604
FIG. 48

Notification control process

Operation input detected?

Yes

Above specified sound volume?

Yes

Specify vibration notification mode

Read waveform data

Instruct to generate drive signal

Reset count value

Instruct to start applying drive signal

Start timing

Count up

Is applied time < specified time?

No

Yes

Instruct to stop applying

END

Yes

No

Specify sound notification mode

Generate beep noise

S601

S602

S603

S604

S605

S606

S607

S608

S609

S610

S611

S612

S613
FIG. 49

FIG. 50

FIG. 51
FIG. 52

CPU

113

102 Touch panel

111 Key input part

112 Memory

103 Display part

114 Drive signal generating circuit

Drive signal

115 Vibration actuator

116

701 Wireless communicating part

603

604

Beep sound generating circuit
FIG. 53

Beacon receiving process

Beacon demodulation \(\sim T101\)

Extract control bit data \(\sim T102\)

Store in memory \(\sim T103\)

END

FIG. 54

<table>
<thead>
<tr>
<th>Mode name</th>
<th>Base station ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration notification mode</td>
<td>BS000001</td>
</tr>
<tr>
<td></td>
<td>BS000159</td>
</tr>
<tr>
<td></td>
<td>BS000439</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
</tbody>
</table>
FIG. 55
FIG. 57

Vibration control process 6

- S701
  - Operation input detected?
    - No
    - S702 Specify touch position
    - S703 Calculate distance between touch position and each vibration actuator
    - S704 Calculate phase for each vibration actuator
    - S705 Read waveform data
    - S706 Instruct to generate drive signal

1

2
FIG. 58

1

- Instruct to stop applying

- END

2

- Reset count value

- Instruct to start applying drive signal

- Start timing

- Count up

- Is applied time < specified time?
  - No: S712
  - Yes: S711
FIG. 59

FIG. 60
FIG. 61

FIG. 62

<table>
<thead>
<tr>
<th>Area data</th>
<th>Distinguishing information for vibration actuator</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>115a</td>
</tr>
<tr>
<td>A2</td>
<td>115b</td>
</tr>
<tr>
<td>A3</td>
<td>115c</td>
</tr>
<tr>
<td>A4</td>
<td>115d</td>
</tr>
<tr>
<td>A5</td>
<td>115a, 115b, 115c, 115d</td>
</tr>
</tbody>
</table>
FIG. 63

Vibration control process 7

Operation input detected?  
No

Yes

Specify touch position

Refer to drive target determination table, and decide on the vibration actuator to drive

Read waveform data

Instruct to generate drive signal

Reset count value

Instruct to start applying drive signal

Start timing

Count up

Is applied time < specified time?  
No

Yes

Instruct to stop applying

END
FIG. 68

FIG. 69

FIG. 70
FIG. 80

995

996

FIG. 81