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Switch simulation device

Abstract

A switch simulation device attachable to a touch panel includes a volume switch including a main body having first and second contact points, a head rotatable around a central axis of the main body and movable in the central axis direction, and an internal opening-and-closing unit electrically coupling and uncoupling the first and second contact points in response to movement of the head in the central axis direction, an operation member including a conductive material and coupled to the head to be rotatable and movable integrally with the head, a contact terminal that includes a conductive material, and is electrically coupled to the first contact point and in continuous contact with the operation member regardless of rotation and movement of the operation member, and a first coupler that electrically couples a first region of the touch panel to the second contact point.

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U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
11226692	12/2021	Su	N/A	G06F 3/041
2023/0145244	12/2022	Clevorn	345/173	G06F 3/016

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2016-218542	12/2015	JP	N/A

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) The present application claims priority from Japanese Patent Application No. 2023-066251 filed on Apr. 14, 2023, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

(2) The present invention relates to a switch simulation device that simulates a physical switch.

Description of Background Art

(3) For example, Japanese Unexamined Patent Application Publication (JP-A) No. 2016-218542 describes a technology for enabling an operation of a touch panel by operating a switch simulation device that is attached to a surface of the touch panel and that simulates a physical switch. The entire contents of this publication are incorporated herein by reference.

SUMMARY OF THE INVENTION

(4) According to one aspect of the present invention, a switch simulation device attachable to a touch panel includes a volume switch including a main body, a head, and an internal opening-and-closing unit, an operation member including a material having electrical conductivity and coupled to the head of the volume switch, a contact terminal that includes a material having electrical conductivity and is electrically coupled to a first contact point of the volume switch, and a first coupler that electrically couples a first region of a touch panel and a second contact point of the volume switch. The main body of the volume switch has the first contact point and the second contact point, the head of the volume switch rotates relative to the main body around a central axis of the main body and moves relative to the main body in a direction in which the central axis of the

main body extends, the internal opening-and-closing unit of the volume switch electrically couples and uncouples the first contact point and the second contact point in response to movement of the head in the direction in which the central axis extends, the operation member rotates and moves integrally with the head, and the contact terminal is in continuous contact with the operation member regardless of rotation of the operation member and movement of the operation member.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

(2) FIG. **1** is a schematic diagram illustrating a configuration of a switch simulation system to which switch simulation devices according to an embodiment of the present invention are applied;

(3) FIG. **2** is a partial plan view illustrating an example of a portion of a surface of a touch panel to which one of the switch simulation devices is attached;

(4) FIG. **3** is a perspective view illustrating an example of a configuration of one of the switch simulation devices;

(5) FIG. **4** is an exploded perspective view illustrating an example of the configuration of one of the switch simulation devices;

(6) FIG. **5** is a longitudinal sectional view illustrating an example of the configuration of one of the switch simulation devices;

(7) FIG. **6** is a longitudinal sectional view illustrating an effect when a rotation operation is performed on one of the switch simulation devices; and

(8) FIG. **7** is a longitudinal sectional view illustrating an effect when a push operation is performed on one of the switch simulation devices.

DETAILED DESCRIPTION OF THE EMBODIMENTS

(9) Embodiments will now be described with reference to the accompanying drawings, wherein like reference numerals designate corresponding or identical elements throughout the various drawings.

(10) In the technology disclosed in JP-A No. 2016-218542, for example, when the push operation with a small pushing force is performed on the operation knob is weak, there is a case where the surface of the touch panel is not appropriately pressed by the end of the operation knob, so that the touch panel cannot be appropriately detect the touch. In other words, in the technology disclosed in JP-A No. 2016-218542, an operation performed on the switch simulation device may sometimes not be appropriately reflected on the touch panel, and there is a possibility that the response accuracy of the touch panel with respect to the operation performed on the switch simulation device may deteriorate.

(11) It is desirable to provide a switch simulation device capable of suppressing deterioration in response accuracy of a touch panel.

(12) An embodiment of the disclosure will be described in detail below with reference to the accompanying drawings. Specific dimensions, materials, numerical values, and so forth that are mentioned in the embodiment are merely examples for ease of understanding of the disclosure and do not limit the disclosure unless otherwise specified. Note that, in the present specification and the drawings, elements that have substantially the same functions and configurations are denoted by the same reference signs to omit repeated descriptions thereof, and elements not directly related to the disclosure are not illustrated.

(13) FIG. **1** is a schematic diagram illustrating a configuration of a switch simulation system **1** to which switch simulation devices **10** according to the present embodiment are applied. The switch

simulation devices **10** are attachable to a surface of a touch panel **12**. FIG. **1** illustrates an example of a state in which the switch simulation devices **10** are attached to the touch panel **12**.
(14) Note that, in FIG. **1**, the three switch simulation devices **10** are attached to the touch panel **12**. However, the number of the switch simulation devices **10** attached to the touch panel **12** is not limited to three and may be one, may be two, or may be four or more.
(15) In response to a touch on the surface of the touch panel **12** by a finger of a person or the like, the touch panel **12** can detect the touch or can determine a touch position on the surface where the touch is performed. The touch panel **12** employs, for example, an electrostatic capacitance method in which a touch position is detected by using a change in electrostatic capacitance corresponding to a touch.
(16) The switch simulation devices **10** are attached to the touch panel **12** such that central axes of the switch simulation devices **10** extend in a direction perpendicular to the surface of the touch panel **12**. Although it will be described later, each of the switch simulation devices **10** is configured to perform both a rotation operation and a push operation. The rotation operation is an operation of rotating the switch simulation device **10** about the central axis of the switch simulation device **10**. The push operation is an operation of pushing the switch simulation device **10** in a direction in which the central axis of the switch simulation device **10** extends.
(17) Each of the switch simulation devices **10** according to the present embodiment is applicable to, for example, an operation panel of a flight simulator. The flight simulator is a device used for, for example, training or experiencing aircraft control without using an actual aircraft but using a simpler simulation device instead. In order to enhance the reality of control, a flight simulator that accurately reproduces a wide range of physical switches similar to those on an operation panel of an actual aircraft may be used. In this case, however, the operation panel of the flight simulator becomes very expensive, and in addition, the versatility of the flight simulator for a model change of an aircraft to be controlled is reduced.
(18) Accordingly, in order to reduce the manufacturing costs of the flight simulator and increase the versatility, using a touch panel having a simple structure and high versatility as the operation panel of the flight simulator may be considered. In the flight simulator using such a touch panel, a control operation of an aircraft is simulated by performing a touch operation on a planar touch panel.
(19) An operation panel of an actual aircraft includes a large number of various physical switches, levers, meters, and the like. Consequently, it is difficult for a flight simulator using a planar touch panel as an operation panel to appropriately simulate actions such as operating a physical switch or the like on an operation panel of an actual aircraft. Thus, there has been a demand for a device capable of enhancing the reality of control while using a touch panel as an operation panel of a flight simulator.
(20) Accordingly, as one application example of the present embodiment, an operation panel in which the switch simulation devices **10** are attached to the touch panel **12** is used as the operation panel of the flight simulator. Although it will be described later, each of the switch simulation devices **10** is attached and fixed to a predetermined position on the surface of the touch panel **12**.
(21) In the switch simulation system **1**, the touch panel **12** can be indirectly operated by operating the switch simulation devices **10**. For example, a user of the switch simulation system **1**, such as a trainee who uses the flight simulator, can obtain the same result as operating the touch panel **12** by operating the switch simulation devices **10**, which are physical devices. Thus, the switch simulation system **1** can appropriately simulate, for example, actions such as operating a physical switch of an actual aircraft.
(22) FIG. **2** is a partial plan view illustrating an example of a portion of the surface of the touch panel **12** to which one of the switch simulation devices **10** is attached.
(23) A first region **20** illustrated by hatching as an example in FIG. **2** and a second region **22** illustrated by cross-hatching as an example in FIG. **2** are set on the surface of the touch panel **12**. The first region **20** is a center region that corresponds to a center portion of the switch simulation

device **10** and is set to have, for example, a circular shape. The second region **22** is a peripheral region that corresponds to an outer edge portion of the switch simulation device **10** and is set to have, for example, an annular shape surrounding the first region **20**. In other words, the first region **20** is set so as to be located inside the second region **22**, which has an annular shape. An inner diameter of the second region **22** is larger than an outer diameter of the first region **20**. A blank region **24** that has an annular shape is formed between an inner peripheral surface of the second region **22** and an outer peripheral surface of the first region **20**.
(24) The switch simulation device **10** is attached to the touch panel **12** so as to be positioned above the first region **20** and the second region **22** of the surface of the touch panel **12**.
(25) The first region **20** is a region for detecting the push operation that is performed on the switch simulation device **10**. The touch panel **12** detects a push operation when, for example, a change in electrostatic capacitance occurs in the first region **20**.
(26) The second region **22** is a region for detecting the rotation operation that is performed on the switch simulation device **10**. For example, when a change in electrostatic capacitance occurs in a part of the second region **22**, the touch panel **12** detects a rotation operation performed at a rotation angle corresponding to the part of the second region **22** in which the change in the electrostatic capacitance has occurred.
(27) Note that the touch panel **12** may detect a push operation when a change in electrostatic capacitance occurs in both the first region **20** and the part of the second region **22**.
(28) FIG. **3** is a perspective view illustrating an example of the configuration of one of the switch simulation devices **10**. FIG. **4** is an exploded perspective view illustrating an example of the configuration of one of the switch simulation devices **10**. FIG. **5** is a longitudinal sectional view illustrating an example of the configuration of one of the switch simulation devices **10**. In FIG. **4** and FIG. **5**, a central axis C**10** of the switch simulation device **10** is indicated by a one-dot chain line. The central axis C**10** of the switch simulation device **10** corresponds to a central axis of the rotation operation of the switch simulation device **10**. The configuration of one of the switch simulation devices **10** will be described below with reference to FIG. **3** to FIG. **5**.
(29) As illustrated in FIG. **4**, the switch simulation device **10** includes a switch base **30**, a volume switch **32**, an operation member **34**, a contact terminal **36**, and a first coupler **38**.
(30) The switch base **30** is detachably attached to the surface of the touch panel **12** and has a function of supporting the switch simulation device **10** on the touch panel **12**. The switch base **30** is formed in a cylindrical shape. A central axis of the switch base **30** coincides with the central axis C**10** of the switch simulation device **10**. An upper end of the switch base **30** is open. As illustrated in FIG. **5**, a lower end of the switch base **30** extends inward in a radial direction, and a through hole **40** is formed at the center of the lower end so as to extend through the lower end in a direction in which the central axis extends. An opening of the through hole **40** is formed in, for example, a circular shape.
(31) The inner diameter of the through hole **40** of the switch base **30** is equal to or larger than the outer diameter of the first region **20** of the touch panel **12** and is smaller than the inner diameter of the second region **22** of the touch panel **12**. An outer diameter of the switch base **30** is equal to or smaller than the inner diameter of the second region **22** of the touch panel **12**.
(32) The lower end of the switch base **30** is attached to the surface of the touch panel **12** and fixed in position. For example, the lower end of the switch base **30** is attached to the surface of the touch panel **12** and fixed in position by any coupling element, such as an adhesive or a double-sided adhesive tape. In more detail, the lower end of the switch base **30** is attached to the blank region **24** between the first region **20** and the second region **22** in the touch panel **12**.
(33) The volume switch **32** includes a main body **50**, a head **52**, and an internal opening-and-closing unit **54**. A central axis of the volume switch **32**, a central axis of the main body **50**, and a central axis of the head **52** coincide with the central axis C**10** of the switch simulation device **10**.
(34) The main body **50** of the volume switch **32** is formed in, for example, a substantially columnar

shape. As illustrated in FIG. **5**, the main body **50** has a first contact point **60** and a second contact point **62** therein. The first contact point **60** and the second contact point **62** are each coupled to one of pins that are exposed to the outside from the inside of the main body **50**.

(35) The head **52** is disposed so as to project upward from an upper surface of the main body **50** and coupled to the main body **50**. The head **52** is made of, for example, an insulating material such as a synthetic resin. Part of an upper end of the head **52** in a circumferential direction has a cutout **64** that is formed so as to be recessed inward in the radial direction. For example, as illustrated in FIG. **4**, the cutout **64** is formed such that the shape of the upper end of the head **52** in plan view when the upper end of the head **52** is viewed from above is a substantially semicircular shape or the like.

(36) The head **52** is configured to rotate relative to the main body **50** around the central axis of the main body **50** and to be movable relative to the main body **50** in a direction in which the central axis of the main body **50** extends. The circumference of the central axis will hereinafter sometimes be referred to as “around the central axis”, and the direction in which the central axis extends will hereinafter sometimes be referred to as the “central axis direction”.

(37) Although it will be described later, when the rotation operation is performed on the switch simulation device **10**, the head **52** of the volume switch **32** rotates around the central axis with respect to the main body **50**. When the push operation is performed on the switch simulation device **10**, the head **52** of the volume switch **32** moves in the central axis direction with respect to the main body **50**.

(38) Note that the volume switch **32** may be configured such that, when the head **52** is rotated around the central axis with respect to the main body **50**, the rotation angle is held in a stepwise manner and temporarily for each predetermined rotation angle. As a result, when the rotation operation is performed on the switch simulation device **10**, a clicking sensation can be provided to an operator for each of the predetermined rotation angles.

(39) The volume switch **32** may be configured to generate, like a tactile switch, a predetermined clicking sensation, that is, tactile feedback when the head **52** is pushed in a direction in which the head **52** is inserted into the main body **50**. As a result, when the push operation is performed on the switch simulation device **10**, a sensation of the push operation can be provided to the operator.

(40) The volume switch **32** may be configured such that, when the head **52** is released from the pushing force in the direction in which the head **52** is inserted into the main body **50**, the head **52** moves in a direction in which the head **52** projects from the main body **50** in such a manner as to return to its original position.

(41) As illustrated in FIG. **5**, the internal opening-and-closing unit **54** is provided inside the main body **50**. The internal opening-and-closing unit **54** is capable of switching, in response to movement of the head **52** in the central axis direction, between a state in which the first contact point **60** and the second contact point **62** are electrically coupled to each other and a state in which the first contact point **60** and the second contact point **62** are electrically uncoupled from each other.

(42) In more detail, in a state where the head **52** is not pushed against the main body **50**, the internal opening-and-closing unit **54** electrically uncouples the first contact point **60** and the second contact point **62** from each other. In contrast, in a state where the head **52** is pushed down with respect to the main body **50** and where the amount of movement of the head **52** is equal to or greater than a predetermined movement amount, the internal opening-and-closing unit **54** electrically couples the first contact point **60** and the second contact point **62** to each other. Note that the predetermined movement amount may be set to a threshold at which a clicking sensation is generated when the head **52** is pushed down with respect to the main body **50**.

(43) The first coupler **38** includes a switch substrate **70**, a touch member **72**, and a biasing member **74**. The switch substrate **70**, the touch member **72**, and the biasing member **74** are accommodated inside the switch base **30**. A central axis of the switch substrate **70**, a central axis of the touch

member **72**, and a central axis of the biasing member **74** coincide with the central axis of the switch simulation device **10**.
(44) The switch substrate **70** is formed in a plate-like shape. The switch substrate **70** is supported by an inner surface of the switch base **30**. The volume switch **32** is disposed on the switch substrate **70**. In more detail, the main body **50** of the volume switch **32** is coupled to the switch substrate **70**. The switch substrate **70** supports the volume switch **32**.
(45) The touch member **72** is made of a material having electrical conductivity. The touch member **72** is formed in, for example, a columnar shape. An outer diameter of a lower end of the touch member **72** is equal to or smaller than the outer diameter of the first region **20** in the touch panel **12**.
(46) The lower end of the touch member **72** is in contact with the surface of the touch panel **12**. In more detail, in a state in which the lower end of the switch base **30** is attached and fixed to the blank region **24** of the touch panel **12**, the lower end of the touch member **72** is in continuous contact with the first region **20** of the touch panel **12**.
(47) The biasing member **74** is, for example, a spring. The biasing member **74** is made of a material having electrical conductivity. The biasing member **74** is disposed between the switch substrate **70** and the touch member **72**. An upper end of the biasing member **74** is coupled to the switch substrate **70**. A lower end of the biasing member **74** is coupled to an upper end of the touch member **72**. The biasing member **74** biases the touch member **72** in a direction in which the touch member **72** is pressed against the touch panel **12**.
(48) The switch substrate **70** has an electrical path that is formed so as to electrically couple the second contact point **62** of the volume switch **32** and the biasing member **74** to each other. For example, among the pins of the main body **50** of the volume switch **32**, the pin coupled to the second contact point **62** is coupled to an electrical circuit that is coupled to the biasing member **74** on the switch substrate **70**.
(49) In this manner, the first coupler **38** electrically couples the first region **20** of the touch panel **12** and the second contact point **62** of the volume switch **32** to each other.
(50) The operation member **34** is made of a material having electrical conductivity. The operation member **34** is coupled to the head **52** of the volume switch **32** so as to be rotatable and movable integrally with the head **52**. The operation member **34** includes a cover **80** and a second coupler **82**.
(51) The cover **80** is mounted on the head **52** of the volume switch **32** so as to cover the volume switch **32**. In more detail, the cover **80** is formed in a cylindrical shape having a closed upper end and an open lower end. A central axis of the cover **80** coincides with the central axis of the switch simulation device **10**.
(52) A recess is formed in an inner surface of the upper end of the cover **80** so as to correspond to the cutout **64** of the head **52**, and the cutout **64** of the head **52** is fitted into the recess. As a result, the cover **80** can move integrally with the head **52**. The cover **80** is made of a material having electrical conductivity.
(53) The second coupler **82** is provided in such a manner as to project downward from the cover **80**, that is, so as to project from the cover **80** toward the touch panel **12**. The second coupler **82** is located outside the switch base **30** in the radial direction. The second coupler **82** includes an arm **90** and a contact member **92**.
(54) The arm **90** extends downward from the cover **80**. A lower end of the arm **90** is bent and projects outward in the radial direction of the cover **80**. The arm **90** is made of a material having electrical conductivity.
(55) The contact member **92** is disposed on a lower surface of the lower end of the arm **90**. The contact member **92** is an end of the second coupler **82**. The contact member **92** is made of, for example, a material such as silicone rubber or electrically conductive fiber that has electrical conductivity and flexibility.
(56) The contact member **92** of the second coupler **82** is in contact with the surface of the touch

panel **12**. In more detail, in a state where the lower end of the switch base **30** is attached and fixed to the blank region **24** of the touch panel **12**, the contact member **92** is in continuous contact with a part of the second region **22** of the touch panel **12**.

(57) In this manner, the second coupler **82** electrically couples the part of the second region **22** of the touch panel **12** and the cover **80** to each other. When the operation member **34** rotates, the contact member **92** of the second coupler **82** is maintained in contact with the second region **22** of the touch panel **12**.

(58) When the push operation is performed on the switch simulation device **10**, the operation member **34** is pushed down and moves downward in the central axis direction. As a result, the end of the second coupler **82**, that is, the contact member **92** also moves downward and is pressed against the surface of the touch panel **12**. Here, the contact member **92** is configured to be deformed in response to movement of the operation member **34** in the central axis direction. For example, when the cover **80** is pushed in a direction toward the touch panel **12**, the contact member **92** is pressed so as to be deformed between the arm **90** and the touch panel **12**.

(59) Thus, in the switch simulation device **10**, even in a state where the second coupler **82** is in continuous contact with the part of the second region **22** of the touch panel **12**, the second coupler **82** can move up and down together with the operation member **34** with a certain allowance, and thus, the push operation may be performed on the operation member **34** without being hindered.

(60) An upper surface of the cover **80** is provided with a direction indicator **94** that indicates a rotation amount of the rotation operation that is performed on the switch simulation device **10**. The direction indicator **94** is formed of, for example, a groove that is recessed downward from the upper surface of the cover **80**. The direction indicator **94** is provided at a position above the second coupler **82**.

(61) The contact terminal **36** is formed in, for example, a bar-like shape. A lower end of the contact terminal **36** is coupled to the switch substrate **70**. An upper end of the contact terminal **36** is in contact with the inner surface of the upper end of the cover **80**. The contact terminal **36** extends obliquely upward from the switch substrate **70** toward the cover **80**. In more detail, the contact terminal **36** extends so as to be inclined with respect to the central axis of the switch simulation device **10** in a direction in which the upper end of the contact terminal **36** is relatively distant from the central axis compared to the lower end.

(62) The lower end of the contact terminal **36** is, for example, bent outward in the radial direction of the switch simulation device **10**. In the contact terminal **36**, a lower surface of the lower end, which is bent, is coupled to the switch substrate **70**. The upper end of the contact terminal **36** is, for example, bent outward in the radial direction of the switch simulation device **10**. In the contact terminal **36**, an upper surface of the upper end, which is bent, is in contact with the inner surface of the upper end of the cover **80**.

(63) The contact terminal **36** is made of a material having electrical conductivity. The contact terminal **36** may be made of a material such as a metal that has relatively high rigidity.

(64) The switch substrate **70** has an electrical path that is formed so as to electrically couple the first contact point **60** of the volume switch **32** and the contact terminal **36** to each other. For example, among the pins of the main body **50** of the volume switch **32**, the pin coupled to the first contact point **60** is coupled to an electrical circuit that is coupled to the contact terminal **36** on the switch substrate **70**.

(65) In this manner, the contact terminal **36** is electrically coupled to the first contact point **60** of the volume switch **32** and is in contact with the inner surface of the cover **80** of the operation member **34** like a train pantograph. Although the upper end of the contact terminal **36** is in elastic contact with the inner surface of the cover **80** of the operation member **34**, the upper end is not fixed to the inner surface. As a result, the contact terminal **36** can be in continuous contact with the cover **80** of the operation member **34** regardless of rotation of the operation member **34** around the central axis and the movement of the operation member **34** in the central axis direction.

(66) Next, an effect relating to the rotation operation of each of the switch simulation devices **10** will be described. As described above, the operation member **34** is made of a material having electrical conductivity, and the contact member **92** is in continuous contact with the part of the second region **22** of the touch panel **12**. Thus, the part of the second region **22** of the touch panel **12** and the operation member **34** are always in a conductive state. The conductive state is a state of being electrically coupled.
(67) As illustrated in FIG. **5**, when a person is not in contact with the operation member **34**, a change in the electrostatic capacitance does not occur in the part of the second region **22** even though the part of the second region **22** of the touch panel **12** and the operation member **34** are in the conductive state. In other words, in this case, although the operation member **34** is in continuous contact with the part of the second region **22**, the touch panel **12** does not detect the rotation operation.
(68) FIG. **6** is a longitudinal sectional view illustrating an effect when the rotation operation is performed on one of the switch simulation devices **10**. FIG. **6** illustrates a case in which a person pinches the cover **80** of the operation member **34** by using their fingers so as to perform the rotation operation.
(69) Since the part of the second region **22** of the touch panel **12** and the operation member **34** are always in the conductive state, when a person touches the cover **80** of the operation member **34**, a current path that is indicated by a dashed arrow A**10** as an example in FIG. **6** is formed. In other words, the current path sequentially coupling the person, the cover **80**, the arm **90**, the contact member **92**, and the second region **22** of the touch panel **12** to one another is formed. As a result, a change in the electrostatic capacitance occurs in the part of the second region **22** of the touch panel **12** with which the contact member **92** is in contact. In response to this, the touch panel **12** detects the rotation angle corresponding to the part, with which the contact member **92** is in contact, in response to the change in the electrostatic capacitance of the part with which the contact member **92** is in contact.
(70) In addition, when the person rotates the cover **80** of the operation member **34**, the second coupler **82** performs a rotational movement around the central axis of the cover **80** along with the rotation of the cover **80**. As a result, the position in the second region **22** of the touch panel **12** at which the contact member **92** is in contact with the surface of the touch panel **12** changes along with the rotation of the cover **80**.
(71) When the cover **80** is rotated, the person keeps touching the cover **80**, and thus, the position in the second region **22** at which the contact member **92** is in contact with the surface of the touch panel **12** changes in a state in which the current path indicated by the dashed arrow A**10** as an example in FIG. **6** is formed. As the position in the second region **22** at which the contact member **92** is in contact with the surface of the touch panel **12** changes, the position in the second region **22** at which a change in the electrostatic capacitance occurs also changes. Accordingly, the touch panel **12** detects, in response to a change of the position at which a change in the electrostatic capacitance occurs, the most recent rotation angle corresponding to the part with which the contact member **92** is currently in contact.
(72) When the fingers that have been in contact with the operation member **34** are released from the operation member **34**, the current path indicated by the dashed arrow A**10** as an example in FIG. **6** is no longer formed. As a result, a change in the electrostatic capacitance does not occur in the second region **22** of the touch panel **12**. Consequently, the touch panel **12** does not detect the rotation angle.
(73) Next, an effect relating to the push operation of each of the switch simulation devices **10** will be described. As described above, the touch member **72** of the first coupler **38** is in continuous contact with the first region **20** of the touch panel **12**. In addition, when the operation member **34** is not pushed down and the head **52** of the volume switch **32** is not pressed downward, the internal opening-and-closing unit **54** of the volume switch **32** is in an open state. When the operation

member **34** is pushed down and the head **52** of the volume switch **32** is pressed in a direction in which the head **52** is inserted into the main body **50**, that is, downward, the internal opening-and-closing unit **54** of the volume switch **32** is brought into a closed state.
(74) As illustrated in FIG. **5**, when the internal opening-and-closing unit **54** of the volume switch **32** is in the open state, the first region **20** of the touch panel **12** and the operation member **34** are in a non-conductive state. The non-conductive state is a state of being not electrically coupled.
(75) In the non-conductive state, since the internal opening-and-closing unit **54** interrupts electrical coupling between the operation member **34** and the first region **20** of the touch panel **12**, a change in the electrostatic capacitance does not occur in the first region **20** even if a person touches the operation member **34**. In other words, when the internal opening-and-closing unit **54** is in the open state, the touch panel **12** does not detect the push operation even though the touch member **72** is in continuous contact with the first region **20**.
(76) FIG. **7** is a longitudinal sectional view illustrating an effect when the push operation is performed on one of the switch simulation devices **10**. FIG. **7** illustrates a case where a person performs the push operation by pushing the upper surface of the cover **80** of the operation member **34** downward by using their finger.
(77) As described above, when the head **52** of the volume switch **32** is pushed in the direction in which the head **52** is inserted into the main body **50**, the internal opening-and-closing unit **54** of the volume switch **32** is brought into the closed state. As illustrated in FIG. **7**, when the internal opening-and-closing unit **54** of the volume switch **32** is in the closed state, the first region **20** of the touch panel **12** and the operation member **34** are in the conductive state.
(78) When the person is in contact with the operation member **34** and the first region **20** of the touch panel **12** and the operation member **34** are brought into the conductive state by the internal opening-and-closing unit **54**, a current path that is indicated by a dashed arrow A**20** as an example in FIG. **7** is formed. In other words, the current path sequentially coupling the person, the cover **80**, the contact terminal **36**, the first contact point **60**, the internal opening-and-closing unit **54**, the second contact point **62**, the biasing member **74**, the touch member **72**, and the first region **20** of the touch panel **12** to one another is formed. As a result, a change in electrostatic capacitance occurs in the first region **20** of the touch panel **12**. In response to this, the touch panel **12** detects the push operation in response to the change in the electrostatic capacitance of the first region **20**.
(79) In addition, since the person is in contact with the operation member **34** when the person performs the push operation, the current path that is indicated by a dashed arrow A**22** as an example in FIG. **7** is also formed. In other words, the current path sequentially coupling the person, the cover **80**, the arm **90**, the contact member **92**, and the second region **22** of the touch panel **12** to one another is also formed. As a result, a change in the electrostatic capacitance occurs also in the part of the second region **22** of the touch panel **12**. Therefore, the touch panel **12** may detect the push operation in response to occurrence of both a change in the electrostatic capacitance of the first region **20** and a change in the electrostatic capacitance of the part of the second region **22**.
(80) Note that, when a change in the electrostatic capacitance of the first region **20** and a change in the electrostatic capacitance of the part of the second region **22** both occur, the touch panel **12** may perform both detection of the push operation and detection of the rotation angle substantially in parallel.
(81) When the pushing force applied to the operation member **34** is reduced, the operation member **34** and the head **52** move so as to return to their original positions before they are pushed, and the internal opening-and-closing unit **54** is switched from the closed state to the open state. As a result, the current path indicated by the dashed arrow A**20** as an example in FIG. **7** is no longer formed. Consequently, the touch panel **12** does not detect the push operation.
(82) As described above, each of the switch simulation devices **10** of the present embodiment includes the volume switch **32**, the operation member **34**, the contact terminal **36**, and the first coupler **38**. The volume switch **32** includes the main body **50**, the head **52**, and the internal

opening-and-closing unit **54**. The main body **50** has the first contact point **60** and the second contact point **62**. The head **52** is configured to rotate relative to the main body **50** around the central axis of the main body **50** and to be movable relative to the main body **50** in the direction in which the central axis of the main body **50** extends. The internal opening-and-closing unit **54** is configured to electrically couple the first contact point **60** and the second contact point **62** to each other or electrically uncoupling the first contact point **60** and the second contact point **62** from each other. The operation member **34** is made of a material having electrical conductivity and coupled to the head **52** of the volume switch **32** so as to be rotatable and movable integrally with the head **52**. The contact terminal **36** is made of a material having electrical conductivity and electrically coupled to the first contact point **60** of the volume switch **32**. The contact terminal **36** is in continuous contact with the operation member **34** regardless of the rotation and the movement of the operation member **34**. The first coupler **38** electrically couples the first region **20** of the touch panel **12** and the second contact point **62** of the volume switch **32** to each other.

(83) Thus, in each of the switch simulation devices **10** of the present embodiment, the internal opening-and-closing unit **54** is opened and closed in response to the push operation performed on the operation member **34**, and when the internal opening-and-closing unit **54** is brought into the open state, the first region **20** of the touch panel **12** and the operation member **34** are electrically coupled to each other. Compared to a comparative example in which a touch operation is detected by pressing an operation knob that is not in contact with the touch panel **12** against the touch panel **12** by performing the push operation, the touch operation can be more appropriately detected by the touch panel **12** in each of the switch simulation devices **10** of the present embodiment.

(84) Therefore, in each of the switch simulation devices **10** of the present embodiment, the push operation that is performed on the switch simulation device **10** can be appropriately reflected on the touch panel **12**, and deterioration in the response accuracy of the touch panel **12** can be suppressed.

(85) In addition, the operation member **34** of each of the switch simulation devices **10** of the present embodiment includes the cover **80** and the second coupler **82**. The cover **80** is mounted on the head of the volume switch **32** and disposed so as to cover the volume switch **32**. The second coupler **82** is disposed so as to project from the cover **80** toward the touch panel **12** and electrically couples the part of the second region **22** of the touch panel **12** and the cover **80** to each other. When the operation member **34** rotates, the end of the second coupler **82** is maintained in contact with the second region **22** of the touch panel **12**.

(86) As a result, in each of the switch simulation devices **10** of the present embodiment, the touch panel **12** can detect the push operation performed on the switch simulation device **10**, and in addition, the touch panel **12** can detect the rotation operation performed on the switch simulation device **10**. As a result, for example, in a flight simulator, a control operation of an actual aircraft can be more accurately simulated with the switch simulation devices **10** of the present embodiment.

(87) In addition, in each of the switch simulation devices **10** of the present embodiment, the end of the second coupler **82** is configured to be deformed in response to the movement of the operation member **34** in the central axis direction.

(88) Consequently, in each of the switch simulation devices **10** of the present embodiment, even in a state where the second coupler **82** is in continuous contact with the part of the second region **22** of the touch panel **12**, a situation in which the push operation is hindered can be avoided, and the push operation is not affected.

(89) In addition, the first coupler **38** of each of the switch simulation devices **10** of the present embodiment includes the touch member **72** that is in continuous contact with the first region **20** of the touch panel **12**. In each of the switch simulation devices **10** of the present embodiment, when the internal opening-and-closing unit **54** is in the open state, the first region **20** of the touch panel **12** and the operation member **34** are in the non-conductive state, and when the internal opening-and-closing unit **54** is in the closed state, the first region **20** of the touch panel **12** and the operation member **34** are in the conductive state.

(90) Thus, in each of the switch simulation devices **10** of the present embodiment, the first coupler **38** is in continuous contact with the first region **20** of the touch panel **12**, so that the electrical coupling between the first coupler **38** and the first region **20** of the touch panel **12** can be more reliably maintained. As a result, compared to the comparative example in which the touch operation is detected by pressing the operation knob, which is not in contact with the touch panel **12**, against the touch panel **12** by performing the push operation, the touch operation can be more appropriately and reliably detected by the touch panel **12** in each of the switch simulation devices **10** of the present embodiment.
(91) In addition, the first coupler **38** of each of the switch simulation devices **10** of the present embodiment includes the switch substrate **70**, the touch member **72**, and the biasing member **74**. The switch substrate **70** is supported by the switch base **30**, which is attached and fixed to the touch panel **12**, and supports the volume switch **32**. The touch member **72** is made of a material having electrical conductivity and is in continuous contact with the first region **20** of the touch panel **12**. The biasing member **74** is made of a material having electrical conductivity and is disposed between the switch substrate **70** and the touch member **72**. The biasing member **74** biases the touch member **72** in the direction in which the touch member **72** is pressed against the touch panel **12**.
(92) Thus, in each of the switch simulation devices **10** of the present embodiment, the touch member **72** can be more reliably brought into continuous contact with the touch panel **12** by the biasing member **74**, and electrical coupling between the second contact point **62** of the volume switch **32** and the touch panel **12** can be more reliably maintained.
(93) Although the embodiment of the disclosure has been described above with reference to the accompanying drawings, the disclosure is not limited to the embodiment. It is obvious that those skilled in the art can conceive various modifications or corrections within the scope described in the claims, and it is to be understood that such modifications or corrections are naturally included in the technical scope of the disclosure.
(94) Note that, in the above-described embodiment, a case has been described in which the operation panel in which the switch simulation devices **10** are attached to the touch panel **12** is used as the operation panel of the flight simulator. However, the switch simulation devices **10** are not limited to be applied to the flight simulator and can be applied to any operation device that includes the touch panel **12**.
(95) In addition, in the above-described embodiment, a case has been described in which the switch simulation devices **10** are each applied as a simulation device of a rotary switch that is capable of detecting the push operation and the rotation operation. However, the disclosure is not limited to this case, and the switch simulation devices **10** can each be applied as a simulation device of other various switches. For example, the configuration for detecting the rotation operation may be omitted, and the switch simulation devices **10** can each be applied as a device that simulates a push switch, a tactile switch, or the like capable of detecting the push operation.
(96) According to the disclosure, deterioration in response accuracy of a touch panel can be suppressed.
(97) For example, Japanese Unexamined Patent Application Publication (JP-A) No. 2016-218542 describes a technology for enabling an operation of a touch panel by operating a switch simulation device that is attached to a surface of the touch panel and that simulates a physical switch. In such a technology, when a push operation is performed on an operation knob that is not in contact with a touch panel, the operation knob moves in a direction toward the touch panel, and an end of the operation knob presses a surface of the touch panel, thereby causing the touch panel to detect a touch.
(98) An aspect of the disclosure provides a switch simulation device attachable to a touch panel. The switch simulation device includes a volume switch, an operation member, a contact terminal, and a first coupler. The volume switch includes a main body, a head, and an internal opening-and-closing unit. The main body includes a first contact point and a second contact point. The head is

configured to rotate relative to the main body around a central axis of the main body and so as to move relative to the main body in a direction in which the central axis of the main body extends. The internal opening-and-closing unit is configured to electrically couple and uncouple the first contact point and the second contact point in response to movement of the head in the direction in which the central axis extends. The operation member includes a material having electrical conductivity and is coupled to the head of the volume switch to be rotatable and movable integrally with the head. The contact terminal includes a material having electrical conductivity and is configured to be electrically coupled to the first contact point of the volume switch. The contact terminal is in continuous contact with the operation member regardless of rotation of the operation member and movement of the operation member. The first coupler is configured to electrically couple a first region of the touch panel and the second contact point of the volume switch.
(99) Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

Claims

1. A switch simulation device attachable to a touch panel, comprising: a volume switch comprising a main body, a head, and an internal opening-and-closing unit; an operation member comprising a material having electrical conductivity and coupled to the head of the volume switch; a contact terminal comprising a material having electrical conductivity and configured to be electrically coupled to a first contact point of the volume switch; and a first coupler configured to electrically couple a first region of a touch panel and a second contact point of the volume switch, wherein the main body of the volume switch has the first contact point and the second contact point, the head of the volume switch is configured to rotate relative to the main body around a central axis of the main body and move relative to the main body in a direction in which the central axis of the main body extends, the internal opening-and-closing unit of the volume switch is configured to electrically couple and uncouple the first contact point and the second contact point in response to movement of the head in the direction in which the central axis extends, the operation member is configured to rotate and move integrally with the head, the contact terminal is in continuous contact with the operation member regardless of rotation of the operation member and movement of the operation member, the operation member comprises a cover mounted on the head of the volume switch and disposed so as to cover the volume switch, and a second coupler disposed so as to project from the cover toward the touch panel and configured to electrically couple a part of a second region of the touch panel and the cover to each other, the second region is around the first region and having an annular shape, and an end of the second coupler is configured to be maintained in contact with the second region of the touch panel when the operation member rotates.
2. The switch simulation device according to claim 1, wherein the end of the second coupler comprises a material having electrical conductivity and flexibility, the end of the second coupler is configured to be deformed in response to movement of the operation member in the direction in which the central axis extends.
3. The switch simulation device according to claim 1, wherein the first coupler comprises a touch member in continuous contact with the first region of the touch panel, the first region of the touch panel and the operation member are configured to be in a non-conductive state when the internal opening-and-closing unit is in an open state, and the first region of the touch panel and the operation member are configured to be in a conductive state when the internal opening-and-closing unit is in a closed state.
4. The switch simulation device according to claim 1, wherein the first coupler comprises a switch substrate supported by a switch base, the switch base is attached and fixed to the touch panel, and

supporting the volume switch, a touch member comprises a material having electrical conductivity, the touch member is in continuous contact with the first region of the touch panel, and a biasing member comprises material having electrical conductivity and disposed between the switch substrate and the touch member, the biasing member is configured to bias the touch member in a direction in which the touch member is pressed against the touch panel, and the switch substrate has an electrical path configured to electrically couple the second contact point of the volume switch and the biasing member to each other.

5. The switch simulation device according to claim 2, wherein the first coupler comprises a touch member in continuous contact with the first region of the touch panel, the first region of the touch panel and the operation member are configured to be in a non-conductive state when the internal opening-and-closing unit is in an open state, and the first region of the touch panel and the operation member are configured to be in a conductive state when the internal opening-and-closing unit is in a closed state.

6. The switch simulation device according to claim 2, wherein the first coupler comprises a switch substrate supported by a switch base, the switch base is attached and fixed to the touch panel, and supporting the volume switch, a touch member comprises a material having electrical conductivity, the touch member is in continuous contact with the first region of the touch panel, and a biasing member comprises material having electrical conductivity and disposed between the switch substrate and the touch member, the biasing member is configured to bias the touch member in a direction in which the touch member is pressed against the touch panel, and the switch substrate has an electrical path configured to electrically couple the second contact point of the volume switch and the biasing member to each other.

7. A switch simulation device attachable to a touch panel, comprising: a volume switch comprising a main body, a head, and an internal opening-and-closing unit; an operation member comprising a material having electrical conductivity and coupled to the head of the volume switch; a contact terminal comprising a material having electrical conductivity and configured to be electrically coupled to a first contact point of the volume switch; and a first coupler configured to electrically couple a first region of a touch panel and a second contact point of the volume switch, wherein the main body of the volume switch has the first contact point and the second contact point, the head of the volume switch is configured to rotate relative to the main body around a central axis of the main body and move relative to the main body in a direction in which the central axis of the main body extends, the internal opening-and-closing unit of the volume switch is configured to electrically couple and uncouple the first contact point and the second contact point in response to movement of the head in the direction in which the central axis extends, the operation member is configured to rotate and move integrally with the head, the contact terminal is in continuous contact with the operation member regardless of rotation of the operation member and movement of the operation member, the first coupler comprises a touch member in continuous contact with the first region of the touch panel, the first region of the touch panel and the operation member are configured to be in a non-conductive state when the internal opening-and-closing unit is in an open state, and the first region of the touch panel and the operation member are configured to be in a conductive state when the internal opening-and-closing unit is in a closed state.

8. A switch simulation device attachable to a touch panel, comprising: a volume switch comprising a main body, a head, and an internal opening-and-closing unit; an operation member comprising a material having electrical conductivity and coupled to the head of the volume switch; a contact terminal comprising a material having electrical conductivity and configured to be electrically coupled to a first contact point of the volume switch; and a first coupler configured to electrically couple a first region of a touch panel and a second contact point of the volume switch, wherein the main body of the volume switch has the first contact point and the second contact point, the head of the volume switch is configured to rotate relative to the main body around a central axis of the main body and move relative to the main body in a direction in which the central axis of the main

body extends, the internal opening-and-closing unit of the volume switch is configured to electrically couple and uncouple the first contact point and the second contact point in response to movement of the head in the direction in which the central axis extends, the operation member is configured to rotate and move integrally with the head, the contact terminal is in continuous contact with the operation member regardless of rotation of the operation member and movement of the operation member, the first coupler comprises a switch substrate supported by a switch base, the switch base is attached and fixed to the touch panel, and supporting the volume switch, a touch member comprises a material having electrical conductivity, the touch member is in continuous contact with the first region of the touch panel, and a biasing member comprises material having electrical conductivity and disposed between the switch substrate and the touch member, the biasing member is configured to bias the touch member in a direction in which the touch member is pressed against the touch panel, and the switch substrate has an electrical path configured to electrically couple the second contact point of the volume switch and the biasing member to each other.