

DESCRIPTION

Title of Invention: PASSENGER BOARDING BRIDGE

Technical Field

[0001] The present invention relates to a passenger boarding bridge.

Background Art

[0002] Conventionally, a passenger boarding bridge is known as equipment that forms a passenger walkway between an aircraft and a terminal building of an airport (see Patent Literatures 1 and 2, for example).

[0003] The passenger boarding bridge includes: a rotunda connected to the terminal building and supported in a turnable manner; a tunnel unit whose proximal end is connected to the rotunda, the tunnel unit including a plurality of tunnels that are fitted together in a telescopic manner, such that the tunnel unit is extendable and retractable; and a turnable cab provided at the distal end of the tunnel unit. Drive columns serving as support legs are further provided at the distal side of the tunnel unit.

[0004] The drive columns are provided with: a lifting/lowering device configured to support the tunnel unit and move the tunnel unit upward/downward; and a running device including a plurality of running wheels, the running device being positioned below the lifting/lowering device. By moving the tunnel unit upward/downward by the lifting/lowering device, the tunnel unit can be swung vertically with respect to the rotunda. By causing the drive columns to run on the apron by means of the running device, the tunnel unit can be extended and retracted in the front-rear direction and/or swung horizontally with respect to the rotunda. The tunnel unit is moved by the drive columns thus configured, and thereby the cab disposed at the front end of the tunnel unit is brought into connection with the entrance of an aircraft. The front end of the floor of the cab is provided with a bumper that is made of synthetic rubber for the purpose of reducing an impact shock when the floor of the cab comes into contact with the aircraft. The cab is connected to the entrance of the aircraft, with the bumper being in contact with the fuselage of the aircraft.

[0005] The aircraft moves upward/downward due to, for example, boarding/disembarking of passengers and loading/unloading of cargo. The passenger boarding bridge includes a level detection device configured to detect the amount of such upward/downward movement of the aircraft. When the amount of upward/downward movement detected by the level detection device is greater than or equal to a predetermined amount, the lifting/lowering device of the

drive columns is controlled such that the cab follows the upward/downward movement of the aircraft.

Citation List

Patent Literature

- [0006] PTL 1: Japanese Laid-Open Utility Model Application Publication No. S62-145800
 PTL 2: Japanese Examined Utility Model Application Publication No. H03-11119

Summary of Invention

Technical Problem

[0007] The aircraft fuselage, which, as mentioned above, comes into contact with the front end bumper of the cab when the cab is connected to the entrance of the aircraft, has a curved surface. For this reason, after the cab is connected to the aircraft, if the aircraft moves upward/downward, a gap may be formed between the bumper and the aircraft, or the pressing force of the bumper applied to the fuselage may become excessively great.

[0008] In the above-described case where the passenger boarding bridge includes the level detection device, when the amount of upward/downward movement of the aircraft is greater than or equal to the predetermined amount, the lifting/lowering device of the drive columns is controlled such that the front end bumper of the cab follows the upward/downward movement of the aircraft. However, even in the case of adopting such a configuration, since the lifting/lowering by the lifting/lowering device causes the tunnel unit and the cab to swing vertically with respect to the rotunda, the front end bumper of the cab is also caused to swing vertically with respect to the rotunda. That is, the front end bumper of the cab does not linearly move in the vertical direction. As a result, a gap may be formed between the bumper and the aircraft, or the pressing force of the bumper applied to the fuselage may become excessively great. If there is such a gap, the passengers may get scared due to the presence of the gap, or some objects may fall through the gap. Moreover, if the pressing force of the bumper applied to the fuselage becomes excessively great, the fuselage may get damaged.

[0009] Patent Literature 1 discloses operating the running device of the drive columns in order to avoid the above problems, i.e., the formation of the gap and the excessive application of the pressing force to the fuselage. However, in reality, it is difficult to finely adjust the space between the cab and the aircraft by controlling the running of the drive columns, which are supporting one end of the passenger boarding bridge, which is heavy in weight.

[0010] The present invention has been made to solve the above-described problems. An

object of the present invention is to provide a passenger boarding bridge that is capable of keeping a suitable contact state between an aircraft and a bumper of a cab even when the aircraft moves upward/downward (i.e., even when the fuselage is lifted/lowered) due to, for example, boarding/disembarking of passengers.

Solution to Problem

[0011] In order to achieve the above object, a passenger boarding bridge according to one aspect of the present invention includes: a rotunda connected to a terminal building; a tunnel unit whose proximal end is connected to the rotunda, the tunnel unit being swingable vertically such that a distal end of the tunnel unit is lifted and lowered; a cab provided at the distal end of the tunnel unit; and a lifting/lowering device configured to support the tunnel unit and lift and lower the tunnel unit. The cab includes: a floor serving as a walkway connected to the tunnel unit; a moving member movable in a passage direction of the walkway relative to the floor; a bumper urged in the passage direction relative to the moving member via an urging member; and a moving mechanism configured to move the moving member in the passage direction relative to the floor. The passenger boarding bridge further includes: a detector configured to detect a contact state between the bumper and the aircraft; and a control device configured to control the moving mechanism when the cab is in a docked state with the aircraft. If the detector detects that the bumper has been brought into a state of being in non-contact with the aircraft, the control device controls the moving mechanism to move the moving member in a direction toward the aircraft, such that the bumper is brought into a state of being in contact with the aircraft with a suitable pressure in a predetermined range. If the detector detects that the bumper in the state of being in contact with the aircraft with a suitable pressure in the predetermined range has been brought into a state of being in contact with the aircraft with an excessive pressure, the control device controls the moving mechanism to move the moving member in a direction away from the aircraft, such that the bumper is brought into the state of being in contact with the aircraft with a suitable pressure in the predetermined range.

[0012] According to the above configuration, if the detector detects that the bumper has been brought into the state of being in non-contact with the aircraft, the control device controls the moving mechanism to move the moving member in a direction toward the aircraft, such that the bumper is brought into the state of being in contact with the aircraft with a suitable pressure in the predetermined range. If the detector detects that the bumper in the state of being in contact with the aircraft with a suitable pressure in the predetermined range has been brought into the state of being in contact with the aircraft with an excessive pressure, the control device

controls the moving mechanism to move the moving member in a direction away from the aircraft, such that the bumper is brought into the state of being in contact with the aircraft with a suitable pressure in the predetermined range. Performing such control makes it possible to keep a suitable contact state between the aircraft and the bumper of the cab even when the aircraft moves upward/downward due to, for example, boarding/disembarking of passengers.

[0013] The passenger boarding bridge may further include a level detection device configured to detect an amount of vertical upward/downward movement of the aircraft relative to the cab after the cab is docked with the aircraft. When the cab is in a docked state with the aircraft, the control device may be configured to control the lifting/lowering device based on a value outputted from the level detection device, such that the cab follows the upward/downward movement of the aircraft.

[0014] According to the above configuration, when the aircraft moves upward/downward due to, for example, boarding/disembarking of passengers, the lifting/lowering device is controlled such that the cab follows the upward/downward movement of the aircraft.

[0015] The detector may include: a first switch configured to operate such that the first switch is turned on or off in accordance with whether or not the bumper is in a state of being in contact with the aircraft; a second switch configured to operate such that the second switch is turned on or off in accordance with whether or not the bumper is in a state of being in contact with the aircraft with a pressure greater than or equal to a lower limit value of the predetermined range; a third switch configured to operate such that the third switch is turned on or off in accordance with whether or not the bumper is in a state of being in contact with the aircraft with a pressure greater than an upper limit value of the predetermined range; and a contact state determiner configured to: determine based on an operation state of the first switch whether or not the bumper is in the state of being in non-contact with the aircraft; and determine based on an operation state of the second switch and an operation state of the third switch whether the bumper is in the state of being in contact with the aircraft with a suitable pressure in the predetermined range or is in the state of being in contact with the aircraft with an excessive pressure.

[0016] The cab may further include a slide plate including two edge portions that are away from each other in the passage direction. Of the two edge portions, one edge portion may be mounted along an upper end of the bumper, and the other edge portion may be placed on a surface of the floor. The slide plate may slide along the surface of the floor in accordance with movement of the bumper.

Advantageous Effects of Invention

[0017] The present invention is configured as described above, and has an advantage of being able to provide a passenger boarding bridge that is capable of keeping a suitable contact state between the aircraft and the bumper of the cab even when the aircraft moves upward/downward (i.e., even when the fuselage is lifted/lowered) due to, for example, boarding/disembarking of passengers.

Brief Description of Drawings

[0018] Fig. 1 is a schematic side view showing one example of a passenger boarding bridge according to one embodiment of the present invention.

Fig. 2 is a schematic plan view showing one example of the front end portion of a cab.

Fig. 3 is a schematic front view showing one example of the cab.

Fig. 4 is a side view showing one example of a state where the cab is docked with an aircraft.

Fig. 5A is a schematic sectional view taken along line A-A of Fig. 2 as viewed in the direction of arrows of line A-A; Fig. 5B is a schematic sectional view taken along line B-B of Fig. 2 as viewed in the direction of arrows of line B-B; and Fig. 5C shows an extendable/retractable bumper unit moved forward from the state shown in Fig. 5B.

Fig. 6A is a sectional view showing, for example, a mounting position of distal end limit switches; Fig. 6B is a sectional view showing, for example, a mounting position of a first limit switch; and Fig. 6C is a sectional view showing, for example, a mounting position of a second limit switch.

Fig. 7 is a flowchart showing one example of operations performed when docking the passenger boarding bridge with the aircraft.

Fig. 8 is a flowchart showing one example of operations performed after the docking of the passenger boarding bridge with the aircraft is completed.

Figs. 9A and 9B are conceptual diagrams for describing operations of a moving mechanism.

Description of Embodiments

[0019] Hereinafter, one preferred embodiment of the present invention is described with reference to the drawings. In the drawings, the same or corresponding elements are denoted by the same reference signs, and repeating the same descriptions is avoided below. The present

invention is not limited to the embodiment described below.

[0020] (Embodiment)

Fig. 1 is a schematic side view showing one example of a passenger boarding bridge according to the present embodiment. Fig. 1 shows a state where the overall length of a tunnel unit 10 is extended.

[0021] Hereinafter, for the sake of convenience of the description, the direction in which the overall length of the tunnel unit 10 of the passenger boarding bridge 100 is extended and retracted is referred to as a front-rear direction; the direction in which the gravitational force is exerted on the passenger boarding bridge 100 is referred to as a vertical direction; and the width direction of the passenger boarding bridge 100 (i.e., the direction orthogonal to the front-rear direction and the vertical direction) is referred to as a right-left direction. In addition, as shown in Fig. 1, the aircraft 200 side of the passenger boarding bridge 100 is referred to as a “front” side, and the terminal building side of the passenger boarding bridge 100 is referred to as a “rear” side in the description below.

[0022] The passenger boarding bridge 100 of the present embodiment includes: a rotunda (a rear round room) 12 connected to an entrance of the terminal building and supported such that the rotunda 12 is turnable about a vertical axis; the tunnel unit 10 whose proximal end is connected to the rotunda 12, the tunnel unit 10 being swingable vertically such that the distal end of the tunnel unit 10 is lifted and lowered; a cab (a front round room) 20 turnably provided at the distal end of the tunnel unit 10; drive columns 15 configured to support the tunnel unit 10 at the distal side of the tunnel unit 10; and auxiliary stairs 16.

[0023] The tunnel unit 10 forms a passenger walkway, and includes a plurality of tubular tunnels 10A and 10B, which are fitted together in a telescopic manner (nested manner), such that the tunnel unit 10 is extendable and retractable.

[0024] A distal-side portion of the tunnel unit 10 (i.e., the tunnel 10B, which is the frontmost tunnel) is provided with the drive columns 15, which serve as support legs. The drive columns 15 are provided with a lifting/lowering device 15A configured to move the tunnel unit 10 upward/downward. By moving the tunnel unit 10 upward/downward by means of the lifting/lowering device 15A, the tunnel unit 10 and the cab 20 can be swung vertically with respect to the rotunda 12.

[0025] The drive columns 15 are further provided with a running device 15B including a plurality of running wheels 14. The running device 15B is positioned below the lifting/lowering device 15A. The running device 15B is configured to be able to run forward and rearward, and the running direction thereof is changeable. By causing the drive columns 15

to run on an apron ground 18 by means of the running device 15B, the tunnel unit 10 can be extended and retracted in the front-rear direction and/or swung horizontally with respect to the rotunda 12.

[0026] The cab 20 is turnably disposed at the front end of the tunnel unit 10. A control board (not shown) is installed in the cab 20, and an operator can operate devices (e.g., drive columns 15) of the passenger boarding bridge 100 by using, for example, a joystick of the control board. The configuration of the cab 20 will be described below in detail.

[0027] The auxiliary stairs 16 are provided on the side of the tunnel unit 10 in a manner to connect between the inside of the tunnel unit 10 and the apron ground 18. The auxiliary stairs 16 are used, for example, to allow the operator to get in and out of the cab 20.

[0028] [Configuration of Cab]

Hereinafter, one example of the cab of the present embodiment is described with reference to the drawings.

[0029] Fig. 2 and Fig. 3 show one example of the cab of the passenger boarding bridge of the present embodiment. Fig. 2 is a schematic plan view of the front end portion of the cab 20 of Fig. 1 as seen in the vertical direction, and Fig. 3 is a schematic front view of the cab 20 of Fig. 1. Fig. 4 is a side view showing one example of a state where the cab is docked with the aircraft.

[0030] The cab 20 includes a walkway 21 and a closure 24.

[0031] The walkway 21 is connected to the passage of the tunnel unit 10 (see Fig. 1). The walkway 21 includes: a fixed floor (not shown) configured to turn in accordance with turning of the cab 20; and a floor 21A (hereinafter, “inclinable floor 21A”) connected to the fixed floor and configured to be inclinable in a width direction 300 relative to the fixed floor. It should be noted that since the inclination mechanism of the inclinable floor 21A is a known mechanism, the inclination mechanism is not described in detail herein, but is described below briefly.

[0032] For example, the fixed floor and the inclinable floor 21A are coupled to each other via, for example, an unshown coupling hinge. The right end portion or left end portion of the inclinable floor 21A is vertically moved by motive force generated by an unshown motive force generator, such as a power cylinder or electric motor. At the time, the front end portion of the inclinable floor 21A can swing about the coupling hinge. In this manner, the inclinable floor 21A can be inclined in the width direction 300.

[0033] It should be noted that the entire floor serving as the walkway 21 of the cab 20, including a portion corresponding to the inclinable floor 21A, may be configured as a fixed floor without the aforementioned inclination mechanism.

[0034] An extendable/retractable bumper unit 30 including a slide plate 32 and a bumper 21B is provided at the front of the floor that serves as the walkway 21 (in this example, at the front of the inclinable floor 21A). The extendable/retractable bumper unit 30 will be described below in detail.

[0035] The closure 24 includes: a bellows portion 24A (see Fig. 4) expandable and contractable in the front-rear direction; a gate-shaped contacting portion 24B provided at the front end of the bellows portion 24A and configured to come into contact with the aircraft 200; and an accommodating portion 24C configured to accommodate the bellows portion 24A when the bellows portion 24A contracts, the accommodating portion 24C being coupled to and integrated with the aforementioned fixed floor or the cab frame. Accordingly, when the cab 20 is brought into connection with (i.e., docked with) the aircraft 200, the contacting portion 24B can come into contact with the aircraft 200 around an entrance 201 thereof by inclining forward.

[0036] A level detection device 25 is disposed on a side wall (specifically, on the accommodating portion 24C) of the cab 20. The level detection device 25 is a device configured to detect the amount of upward/downward movement of the aircraft 200 relative to the cab 20 when the aircraft 200 moves upward/downward due to, for example, boarding/disembarking of passengers or loading/unloading of cargo after the cab 20 is connected to the entrance 201 of the aircraft 200.

[0037] For example, the level detection device 25 includes, for example, a wheel 25A and a contact limit switch (not shown) intended for when the wheel 25A moves forward.

[0038] The contact limit switch is pre-adjusted such that the pressure of the wheel 25A applied to the surface of the fuselage of the aircraft 200 is optimal. In a case where the wheel 25A moves forward, the forward movement can be stopped at a desirable moving amount as a result of the contact limit switch being turned ON. This allows the level detection device 25 to press the wheel 25A against the surface of the fuselage of the aircraft 200 with an optimal pressure. The wheel 25A of the level detection device 25 rotates when the aircraft 200 moves upward or downward. The level detection device 25 includes a detector configured to detect the amount of upward/downward movement of the aircraft 200 relative to the cab 20 based on the rotation direction and rotation angle of the wheel 25A (hereinafter, the amount of upward/downward movement of the aircraft 200 relative to the cab 20 is also referred to as “upward/downward moving amount of the aircraft 200”). When the upward/downward moving amount of the aircraft 200 detected by the detector is greater than or equal to a predetermined amount, the level detection device 25 outputs the detected upward/downward moving amount of the aircraft 200 to a control device 50. The control device 50 controls the lifting/lowering

device 15A of the drive columns 15 such that the cab 20 follows the upward/downward movement of the aircraft 200.

[0039] Next, the configurations of the extendable/retractable bumper unit 30 and so forth provided at the front of the inclinable floor 21A of the cab 20 are described with reference to Fig. 2, Figs. 5A to 5C, and Figs. 6A to 6C.

[0040] Fig. 5A is a schematic sectional view taken along line A-A of Fig. 2 as viewed in the direction of arrows of line A-A. Fig. 5B is a schematic sectional view taken along line B-B of Fig. 2 as viewed in the direction of arrows of line B-B. Fig. 5C shows the extendable/retractable bumper unit 30 moved forward from the state shown in Fig. 5B. It should be noted that Figs. 5A to 5C do not show distal end limit switches LSf (see Fig. 2).

[0041] The extendable/retractable bumper unit 30 includes: the bumper 21B; the slide plate 32; a connecting member 33; extendable/compressible urging members 34; and a moving member 35. For example, coil springs can be used as the urging members 34.

[0042] The bumper 21B is disposed away from the inclinable floor 21A in a passage direction 400 of the walkway, and is mounted such that the bumper 21B is movable in the passage direction 400 relative to the inclinable floor 21A. The bumper 21B is disposed at the distal end of the cab 20, and the front portion of the bumper 21B comes into contact with the aircraft when the cab 20 is docked with the aircraft. The bumper 21B is made of synthetic rubber, and is a buffer member that has a function of reducing an impact shock when the cab 20 comes into contact with the aircraft 200. It should be noted that the passage direction 400 is a direction in which the passengers on the walkway 21 walk, and is a direction perpendicular to the width direction 300 (see Fig. 2) of the inclinable floor 21A. In Fig. 2, the passage direction 400 is the front-rear direction.

[0043] The slide plate 32 is a rectangular plate-shaped member extending rearward from the upper end of the bumper 21B and having a predetermined width. The slide plate 32 includes two edge portions 32a and 32b, which are opposite edge portions away from each other in the passage direction 400. Of the two edge portions 32a and 32b, one front edge portion 32a is mounted along the upper end of the bumper 21B, and the other rear edge portion 32b is placed and supported on the surface of the inclinable floor 21A such that the rear edge portion 32b is slidable along the surface of the inclinable floor 21A in accordance with movement of the bumper 21B. The passengers can walk on the slide plate 32.

[0044] The connecting member 33 is fixed to the lower surface of the front end portion of the slide plate 32. The bumper 21B is mounted to the front surface of the connecting member 33, and one end of each of a plurality of (in the example of Fig. 2, six) urging members 34 is

fixed to the rear surface of the connecting member 33. The other end of each of the plurality of urging members 34 is fixed to the plate-shaped moving member 35, which is disposed perpendicularly to the slide plate 32. That is, the plurality of urging members 34 urge the slide plate 32 and the bumper 21B forward relative to the moving member 35. Thus, the bumper 21B and the moving member 35 are urged away from each other in the passage direction 400 by the plurality of urging members 34. It should be noted that the slide plate 32 is slidable on the moving member 35, and is not fixed to the moving member 35.

[0045] The moving member 35 is disposed below the slide plate 32 and at the rear side of the bumper 21B. In this example, at a position forward of a front end portion 21At of the inclinable floor 21A, the moving member 35 can be moved in the passage direction 400 relative to the inclinable floor 21A by a moving mechanism 31 described below.

[0046] The moving mechanism 31, which is configured to move the moving member 35 of the extendable/retractable bumper unit 30 in the passage direction 400 relative to the inclinable floor 21A, is provided below the inclinable floor 21.

[0047] The moving mechanism 31 includes, for example, a rack mounting member 36, racks 37, pinions 38, a shaft 39, a motor 40, and a motor support member 41. The rack mounting member 36, which extends in the passage direction 400, is fixed to the rear surface of the moving member 35. The racks 37 are fixed to the rack mounting member 36.

[0048] The pinions 38, which form a rack-and-pinion mechanism together with the racks 37, are fixed to the shaft 39. The shaft 39 is supported by suitably provided bearings 42 (see Fig. 2). As shown in Fig. 2, two sets of the rack 37 and the pinion 38 are provided. Specifically, one set of the rack 37 and the pinion 38 is provided on one end, and the other set of the rack 37 and the pinion 38 is provided on the other end, of the shaft 39 extending in the width direction 300 of the inclinable floor 21A. The motor 40 is fixed below the inclinable floor 21A by the motor support member 41 and the like, and the rotational force of the motor 40 is transmitted to the shaft 39 via, for example, a coupling.

[0049] Specifically, when the motor 40 rotates, the shaft 39 and the pinions 38 rotate. The rotation of the pinions 38 causes the racks 37 to move in the passage direction 400 parallel to the surface of the inclinable floor 21A. At the time, the moving member 35 and the rack mounting member 36 move together with the racks 37. It should be noted that suitable guide members (not shown) are provided so that these components can move in the passage direction 400.

[0050] In addition, the slide plate 32 and the bumper 21B, which are coupled to each other by the moving member 35 and the urging members 34, are provided with suitable guide members (not shown) so that the slide plate 32 can slide in the passage direction 400 along the

surface of the inclinable floor 21A when the moving member 35 moves in the passage direction 400 and/or when the urging members 34 are extended or compressed.

[0051] Figs. 5A and 5B each show a state where the racks 37 are at their rearmost positions, and Fig. 5C shows a state where the racks 37 have moved forward.

[0052] When the motor 40 is in a stopped state, the moving member 35 is in a stationary state. At the time, if rearward force is applied to the bumper 21B, the urging members 34 are compressed, and the slide plate 32 and the bumper 21B are configured such that the slide plate 32 slides rearward along the surface of the inclinable floor 21A.

[0053] It should be noted that the moving mechanism 31 is not limited to the above-described example. The moving mechanism 31 may be configured in any manner, so long as the moving mechanism 31 is capable of moving the moving member 35 of the extendable/retractable bumper unit 30 in the passage direction 400. In the description below, moving the moving member 35 in a direction away from the inclinable floor 21A (i.e., in a direction toward the aircraft 200) by the moving mechanism 31 is also referred to as moving the extendable/retractable bumper unit 30 forward, and also, moving the moving member 35 in a direction toward the inclinable floor 21A (i.e., in a direction away from the aircraft 200) is also referred to as moving the extendable/retractable bumper unit 30 rearward (i.e., reversing).

[0054] As shown in Fig. 2, a plurality of (in the example of Fig. 2, three) limit switches LSf (which may hereinafter be referred to as “distal end limit switches LSf”), a first limit switch LS1, and a second limit switch LS2 are provided for use in, for example, the control of the moving mechanism 31.

[0055] Fig. 6A is a sectional view showing, for example, a mounting position of the distal end limit switches LSf. Fig. 6B is a sectional view showing, for example, a mounting position of the first limit switch LS1. Fig. 6C is a sectional view showing, for example, a mounting position of the second limit switch LS2.

[0056] As shown in Fig. 6A, the distal end limit switches LSf are mounted to the lower end of the connecting member 33, and are intended for detecting that the bumper 21B has come into contact with the fuselage of the aircraft 200. Specifically, when the bumper 21B comes into contact with the fuselage of the aircraft 200 and the fuselage comes into contact with the distal end limit switches LSf, the distal end limit switches LSf are turned ON. Fig. 6A shows a case where the cab 20 is not in a docked state with the aircraft 200. In this case, the distal end limit switches LSf are OFF, and the urging members 34 are in an extended state.

[0057] As thus described, the plurality of distal end limit switches LSf are provided. However, not necessarily all the distal end limit switches LSf are turned ON when the bumper

21B comes into contact with the fuselage of the aircraft 200, depending on the shape and so forth of the fuselage of the aircraft 200. Therefore, state signals of all the distal end limit switches LSf (i.e., an ON signal or OFF signal of each of the distal end limit switches LSf) are inputted to the control device 50, and if the state signals indicate that at least one of the distal end limit switches LSf is ON, the control device 50 determines that the distal end limit switches LSf are ON, whereas if the state signals indicate that all the distal end limit switches LSf are OFF, the control device 50 determines that the distal end limit switches LSf are OFF.

[0058] As shown in Fig. 6B, the first limit switch LS1 is mounted to the front surface of the moving member 35. A contact member 51 for turning ON the first limit switch LS1 is mounted to the connecting member 33 via a fixing member 52.

[0059] In a state where the bumper 21B is in contact with the fuselage of the aircraft 200 and the distal end limit switches LSf are ON, if the urging members 34 are compressed such that the bumper 21B and the slide plate 32 slide rearward to bring the contact member 51 into contact with the first limit switch LS1, the first limit switch LS1 is turned ON. Fig. 6B shows a state immediately after the first limit switch LS1 is turned ON.

[0060] As shown in Fig. 6C, similar to the first limit switch LS1, the second limit switch LS2 is mounted to the front surface of the moving member 35. A contact member 53 for turning ON the second limit switch LS2 is mounted to the connecting member 33 via a fixing member 54.

[0061] The contact member 51 of the first limit switch LS1 and the contact member 53 of the second limit switch LS2 are provided such that each of these contact members extends rearward from a position that is away from the connecting member 33 by a predetermined distance. The contact member 51 of the first limit switch LS1 extends rearward further than the contact member 53 of the second limit switch LS2 does.

[0062] Accordingly, in a state where the bumper 21B is in contact with the fuselage of the aircraft 200 and the distal end limit switches LSf are ON, if the first limit switch LS1 is further turned ON and then the urging members 34 are further compressed such that the bumper 21B and the slide plate 32 slide rearward to bring the contact member 53 into contact with the second limit switch LS2, the second limit switch LS2 is turned ON. Fig. 6C shows a state immediately after the second limit switch LS2 is turned ON. It should be noted that the moving member 35 is provided with a clearance portion (e.g., a hole or a groove) so that the contact member 51 of the first limit switch LS1 and the fixing member 52 will not come into contact or collision with the moving member 35 in the state shown in Fig. 6C.

[0063] As described above, when the bumper 21B comes into contact with the fuselage of

the aircraft 200, first, the distal end limit switches LSf are turned ON. Then, when the bumper 21B is pressed against the fuselage of the aircraft 200, the urging members 34 are compressed, and thereby the first limit switch LS1 is further turned ON. Thereafter, when the urging members 34 are further compressed, the second limit switch LS2 is further turned ON.

[0064] That is, when the bumper 21B comes into contact with the fuselage of the aircraft 200, the degree of compression of the urging members 34 increases in accordance with increase in pressing force applied from the fuselage to the bumper 21B, and as a result, the distal end limit switches LSf, the first limit switch LS1, and the second limit switch LS2 are sequentially turned ON in this order. On the other hand, from the state where these limit switches LSf, LS1, and LS2 are ON, the urging members 34 extend in accordance with decrease in the pressing force applied from the fuselage to the bumper 21B, and as a result, the second limit switch LS2, the first limit switch LS1, and the distal end limit switches LSf are sequentially turned OFF in this order.

[0065] Here, when the first limit switch LS1 is ON, the distal end limit switches LSf are always ON, and when the second limit switch LS2 is ON, the distal end limit switches LSf and the first limit switch LS1 are always ON.

[0066] As described above, the cab 20 includes: the extendable/retractable bumper unit 30; the moving mechanism 31 configured to move the extendable/retractable bumper unit 30; and the limit switches LSf, LS1, and LS2 used for, for example, the control of the moving mechanism 31.

[0067] The control device 50 (see Fig. 3) of the passenger boarding bridge 100 is disposed in the cab 20. The control device 50 may be configured in any manner, so long as the control device 50 has control functions. The control device 50 includes, for example, an arithmetic operation unit such as a CPU and a storage unit including a ROM, RAM, etc. A control program for operating the components of the passenger boarding bridge 100 and information necessary for the operations of these components are prestored in the storage unit. The arithmetic operation unit (CPU) can control the operations of the components of the passenger boarding bridge 100 by executing the control program in accordance with, for example, operation information from the control board. Information to be stored while the passenger boarding bridge 100 is in operation is also stored in the storage unit. The control device 50 may be configured as a single controller, or may be configured as a plurality of controllers.

[0068] For example, as previously mentioned, the control device 50 controls the lifting/lowering device 15A of the drive columns 15 based on a value (an upward/downward moving amount of the aircraft 200) outputted from the level detection device 25, such that the

cab 20 docked with the entrance 201 of the aircraft 200 follows the upward/downward movement of the aircraft 200.

[0069] The control device 50 receives state signals of the distal end limit switches LSf, the first limit switch LS1, and the second limit switch LS2 (i.e., an ON signal or OFF signal of each of the limit switches), and controls the moving mechanism 31 (the motor 40). Operations of the control device 50 are described below in detail.

[0070] [Operations]

Next, one example of operations of the passenger boarding bridge 100 is described. Operations of the passenger boarding bridge 100 are realized by control performed by the control device 50.

[0071] First, one example of operations performed when docking the passenger boarding bridge 100 with the aircraft 200 is described. Fig. 7 is a flowchart showing one example of operations performed when docking the passenger boarding bridge with the aircraft. Fig. 7 shows operations that are performed when the passenger boarding bridge 100 moves from a parking position to a predetermined target position that is a position for docking the passenger boarding bridge 100 with the aircraft 200. It should be noted that steps S1 to S8 shown in Fig. 7 may be the same as operations of a known automatic docking function. However, part or all of the operations can be manually executed by an operator.

[0072] In step S1, the operator pushes an aircraft type selection button provided on the control board to select the aircraft type of the aircraft 200. Based on the selected aircraft type, a target position corresponding to the aircraft type is selected from among a plurality of target positions that are set in advance corresponding to a plurality of aircraft types. For example, the target position is a position that is located in front of the entrance of the aircraft, but is away from the entrance of the aircraft by a predetermined distance.

[0073] Next, when the operator pushes a start button on the control board, automatic control described below is started. It should be noted that, in the present embodiment, the start button is in an ON state only while the operator is pushing the button, i.e., configured as a dead man's switch. Accordingly, when the operator releases their hand from the button, the automatic control described below is stopped forcibly.

[0074] In step S2, based on the above selection of the aircraft type and detection results from any suitable angle sensor (not shown) and position sensor (not shown), various control amounts to reach the target position (e.g., a turning angle of the cab 20, an upward/downward moving amount of the tunnel unit 10, and a turning angle and a running distance of the running device 15B of the drive columns 15) are calculated.

[0075] Next, based on the calculation results, the cab 20 is turned in step S4, and the tunnel unit 10 is moved upward/downward by the lifting/lowering device 15A of the drive columns 15 in step S5.

[0076] At the same time, the running device 15B is controlled in steps S3 and S6. Specifically, in step S3, the running device 15B is turned such that the running direction of the running device 15B is the direction toward the target position, and then in step S6, the running device 15B is caused to run on the apron ground 18 in this direction.

[0077] Next, in step S7, based on a detection result from a photoelectric distance sensor (not shown) provided on the cab 20, it is determined whether or not the distance between the cab 20 and the aircraft 200 is a predetermined distance set in advance (e.g., 1 m).

[0078] If the determination result in step S7 is NO, the above-described operation is kept performed. On the other hand, if the determination result in step S7 is YES, the flow proceeds to step S8.

[0079] In step S8, inclination angle automatic control of the inclinable floor 21A of the cab 20 in the width direction 300 is performed based on an output signal from an angle adjustment detector (not shown) that detects the inclination angle of the inclinable floor 21A in the width direction 300. Specifically, the motive force generator is controlled based on the output signal from the angle adjustment detector, such that the inclination angle of the inclinable floor 21A is a predetermined target value. For example, the motive force generator is controlled such that the inclinable floor 21A is parallel to the apron ground 18. Accordingly, if the floor surface of the inclinable floor 21A of the cab 20 and a floor surface 201A (see Fig. 4) of the entrance 201 of the aircraft 200 are not parallel to each other, the control device 50 automatically controls the inclination angle of the inclinable floor 21A in the width direction 300 based on the output signal from the angle adjustment detector.

[0080] Thereafter, the operator uses the control board to perform an operation of moving the running device 15B forward to bring the bumper 21B of the cab 20 into contact with the aircraft 200. At the time, the control device 50 causes the running device 15B to move forward, and when the distal end limit switches LSf are turned ON, stops the running device 15B. Then, the control device 50 controls the moving mechanism 31 to move the extendable/retractable bumper unit 30 forward, and when the first limit switch LS1 is turned ON, stops the moving mechanism 31. Thereafter, the control device 50 causes the bellows portion 24A of the closure 24 to expand forward, such that the contacting portion 24B inclines forward and comes into contact with the aircraft 200 around the entrance 201 thereof. In this manner, the cab 20 is docked with the entrance 201 of the aircraft 200. That is, the docking of the passenger boarding bridge 100

with the aircraft 200 is completed.

[0081] Described next is one example of operations performed after the docking of the passenger boarding bridge 100 with the aircraft 200 is completed. Fig. 8 is a flowchart showing one example of operations performed after the docking of the passenger boarding bridge 100 with the aircraft 200 is completed.

[0082] Fig. 8 shows operations that are performed after the passenger boarding bridge 100 is set to an automatic leveling mode through an operation manually executed by the operator using a switch (not shown) on the control board. When the passenger boarding bridge 100 is set to the automatic leveling mode, the level detection device 25 starts operating and the wheel 25A thereof moves forward to be in a state where the wheel 25A is in contact with the surface of the fuselage of the aircraft 200 with an optimal pressure. When the passenger boarding bridge 100 is set to the automatic leveling mode (i.e., immediately after the docking of the passenger boarding bridge 100 with the aircraft 200 is completed), the distal end limit switches LSf and the first limit switch LS1 are ON, and the second limit switch LS2 is OFF.

[0083] In the automatic leveling mode, the control device 50 performs detection based on a value (an upward/downward moving amount of the aircraft 200) outputted from the level detection device 25. That is, when the upward/downward moving amount of the aircraft 200 becomes greater than or equal to a predetermined amount, the control device 50 determines that lifting or lowering of the fuselage of the aircraft 200 is detected (step S11, S13). If lifting of the fuselage is detected (YES in step S11), the control device 50 performs lifting control of the lifting/lowering device 15A based on the aforementioned value outputted from the level detection device 25 to lift the tunnel unit 10, such that the cab 20 follows the lifting of the fuselage (step S12). On the other hand, if lowering of the fuselage is detected (YES in step S13), the control device 50 performs lowering control of the lifting/lowering device 15A based on the aforementioned value outputted from the level detection device 25 to lower the tunnel unit 10, such that the cab 20 follows the lowering of the fuselage (step S14).

[0084] Next, the control device 50 determines the state of the distal end limit switches LSf and the state of the second limit switch LS2 (steps S15 and S17). If the state of the distal end limit switches LSf changes from ON to OFF (YES in step S15), then in step S16, the control device 50 controls the moving mechanism 31 to move the extendable/retractable bumper unit 30 forward until the first limit switch LS1 is turned ON. On the other hand, if the state of the second limit switch LS2 changes from OFF to ON (YES in step S17), then in step S18, the control device 50 controls the moving mechanism 31 to move the extendable/retractable bumper unit 30 rearward (i.e., reversing) by a distance (a predetermined amount) set in advance, thereby

turning OFF the second limit switch LS2 (while keeping the ON state of the first limit switch LS1).

[0085] Although steps S11 and S13 are shown as separate steps in Fig. 8, these determinations are performed concurrently based on the value outputted from the level detection device 25 as described above. Although steps S15 and S16 are performed prior to steps S17 and S18 in Fig. 8, steps S17 and S18 may be performed prior to steps S15 and S16.

[0086] Described next is a specific example of operations of the moving mechanism 31 that are related to steps S15 to S18. Figs. 9A and 9B are conceptual diagrams for describing the operations of the moving mechanism 31. In these diagrams, the fuselage of the aircraft 200 is drawn as a circle, and the passenger boarding bridge 100 is drawn as a straight line. These diagrams do not show actual shapes, dimensional ratios, etc., of the fuselage of the aircraft 200 and the passenger boarding bridge 100. In Figs. 9A and 9B, a reference sign “12C” indicates a reference point, with respect to which the tunnel unit 10 of the passenger boarding bridge 100 is swung vertically by the lifting/lowering device 15A (i.e., the reference point at which the tunnel unit 10 is connected to the rotunda 12). A reference sign “200C” indicates a suitable contact portion of the aircraft 200, the contact portion coming into contact with the distal-end bumper 21B of the cab 20.

[0087] For example, in Fig. 9A, in a case where the aircraft 200 is lifted from a position indicated by solid line to a position indicated by two-dot chain line due to, for example, disembarking of passengers or unloading of cargo, the passenger boarding bridge 100 is moved from a position indicated by solid line to a position indicated by two-dot chain line.

[0088] At the time, assuming that the length of the passenger boarding bridge 100 is fixed to a length indicated by solid line, then the bumper 21B moved by the lifting control of the lifting/lowering device 15A moves on an arc C1 about the reference point 12C. As a result, a gap is formed between the arc C1 (i.e., the bumper 21B) and the two-dot chain line representing the aircraft 200. However, in the present embodiment, first, the urging members 34 extend to move the bumper 21B forward, and then, when the distal end limit switches LSf are turned OFF (YES in step S15), the moving mechanism 31 is controlled to move the extendable/retractable bumper unit 30 forward until the first limit switch LS1 is turned ON (step S16). In this manner, the bumper 21B is moved forward, and a suitable contact state between the bumper 21B and the aircraft 200 is kept (i.e., the passenger boarding bridge 100 is brought into a state indicated by two-dot chain line).

[0089] On the other hand, in Fig. 9A, in a case where the aircraft 200 is lowered from the position indicated by two-dot chain line to the position indicated by solid line due to, for

example, boarding of passengers or loading of cargo, the passenger boarding bridge 100 is moved from the position indicated by two-dot chain line to the position indicated by solid line.

[0090] At the time, assuming that the length of the passenger boarding bridge 100 is fixed to a length indicated by two-dot chain line, then conversely to the above-described case, the bumper 21B moved by the lowering control of the lifting/lowering device 15A is pressed hard to the fuselage of the aircraft 200, which may cause damage to the fuselage. However, in the present embodiment, first, the urging members 34 are compressed to move the bumper 21B rearward, and then, when the second limit switch LS2 is turned ON (YES in step S17), the moving mechanism 31 is controlled to move the extendable/retractable bumper unit 30 rearward (i.e., reversing) (step S18). In this manner, the bumper 21B is moved rearward, and a suitable contact state between the bumper 21B and the aircraft 200 is kept (i.e., the passenger boarding bridge 100 is brought into a state indicated by solid line).

[0091] In Fig. 9A, regardless of whether the aircraft 200 is lifted or lowered, the passenger boarding bridge 100 forms an upward slope from the reference point 12C in the direction toward the aircraft 200. Conversely, in Fig. 9B, regardless of whether the aircraft 200 is lifted or lowered, the passenger boarding bridge 100 forms a downward slope from the reference point 12C in the direction toward the aircraft 200.

[0092] In Fig. 9B, in a case where the aircraft 200 is lifted from a position indicated by solid line to a position indicated by two-dot chain line due to, for example, disembarking of passengers or unloading of cargo, the passenger boarding bridge 100 is moved from a position indicated by solid line to a position indicated by two-dot chain line.

[0093] At the time, assuming that the length of the passenger boarding bridge 100 is fixed to a length indicated by solid line, then the bumper 21B moved by the lifting control of the lifting/lowering device 15A moves on an arc C2 about the reference point 12C. As a result, the arc C2 (i.e., the bumper 21B) cuts into the two-dot chain line representing the aircraft 200. That is, the bumper 21B is pressed hard to the fuselage of the aircraft 200, which may cause damage to the fuselage. However, in the present embodiment, first, the urging members 34 are compressed to move the bumper 21B rearward, and then, when the second limit switch LS2 is turned ON (YES in step S17), the moving mechanism 31 is controlled to move the extendable/retractable bumper unit 30 rearward (i.e., reversing) (step S18). In this manner, the bumper 21B is moved rearward, and a suitable contact state between the bumper 21B and the aircraft 200 is kept (i.e., the passenger boarding bridge 100 is brought into a state indicated by two-dot chain line).

[0094] On the other hand, in Fig. 9B, in a case where the aircraft 200 is lowered from the

position indicated by two-dot chain line to the position indicated by solid line due to, for example, boarding of passengers or loading of cargo, the passenger boarding bridge 100 is moved from the position indicated by two-dot chain line to the position indicated by solid line.

[0095] At the time, assuming that the length of the passenger boarding bridge 100 is fixed to a length indicated by two-dot chain line, then conversely to the above-described case, a gap is formed between the aircraft 200 and the bumper 21B moved by the lowering control of the lifting/lowering device 15A. However, in the present embodiment, first, the urging members 34 extend to move the bumper 21B forward, and then, when the distal end limit switches LSf are turned OFF (YES in step S15), the moving mechanism 31 is controlled to move the extendable/retractable bumper unit 30 forward until the first limit switch LS1 is turned ON (step S16). In this manner, the bumper 21B is moved forward, and a suitable contact state between the bumper 21B and the aircraft 200 is kept (i.e., the passenger boarding bridge 100 is brought into a state indicated by solid line).

[0096] As described above, Fig. 9A shows an example case where regardless of whether the aircraft 200 is lifted or lowered, the passenger boarding bridge 100 forms an upward slope, and Fig. 9B shows an example case where regardless of whether the aircraft 200 is lifted or lowered, the passenger boarding bridge 100 forms a downward slope. However, there are not only these cases but also other cases. There may be a case where when the aircraft 200 is lifted, the passenger boarding bridge 100 forms an upward slope or is brought into a horizontal state, and when the aircraft 200 is lowered, the passenger boarding bridge 100 forms a downward slope. There may be a case where when the aircraft 200 is lifted, the passenger boarding bridge 100 forms an upward slope, and when the aircraft 200 is lowered, the passenger boarding bridge 100 is brought into a horizontal state. Also in these cases, if the passenger boarding bridge 100 includes the extendable/retractable bumper unit 30 and the moving mechanism 31, and the moving mechanism 31 and the lifting/lowering device 15A are controlled in the above-described manner as in the present embodiment, a suitable contact state between the bumper 21B and the aircraft 200 can be kept even when the aircraft 200 moves upward/downward.

[0097] It should be noted that, in Fig. 8, step S15 and step S17 are performed when lifting or lowering of the fuselage is detected (YES in step S11 or in step S13). However, not only in this case, but also in a case where it is determined NO in step S11 and in step S13, step S15 and step S17 may be performed. For example, if it is determined NO in step S13 of Fig. 8, the flow may proceed to step S15 without returning to step S11.

[0098] It should be noted that, in the present embodiment, among first to third switches included in a detector that detects a contact state between the bumper 21B and the aircraft 200,

the first switch corresponds to the distal end limit switches LSf, the second switch corresponds to the first limit switch LS1, and the third switch corresponds to the second limit switch LS2.

[0099] Also, the control device 50 has a function as a contact state determiner included in the above detector. As described above, at a point when the cab 20 is docked with the aircraft 200 (i.e., at a point when the automatic leveling mode is started), the distal end limit switches LSf and the first limit switch LS1 are ON, and the second limit switch LS2 is OFF. From this state, if all the distal end limit switches LSf are turned OFF (at the time, the first limit switch LS1 is also turned OFF), the control device 50 determines that the bumper 21B is in the state of being in non-contact with the aircraft 200, but if at least one of the distal end limit switches LSf is ON, the control device 50 determines that the bumper 21B is in the state of being in contact with the aircraft 200. When the first limit switch LS1 is ON and the second limit switch LS2 is OFF, the control device 50 determines that the bumper 21B is in the state of being in contact with the aircraft 200 with a suitable pressure in a predetermined range. From this state, if both the first limit switch LS1 and the second limit switch LS2 are turned ON, the control device 50 determines that the bumper 21B has been brought into the state of being in contact with the aircraft 200 with an excessive pressure (i.e., a pressure greater than the upper limit value of the aforementioned predetermined range). Then, based on these determination results, the control device 50 controls the moving mechanism 31.

[0100] From the foregoing description, numerous modifications and other embodiments of the present invention are obvious to a person skilled in the art. Therefore, the foregoing description should be interpreted only as an example and is provided for the purpose of teaching the best mode for carrying out the present invention to a person skilled in the art. The structural and/or functional details may be substantially altered without departing from the spirit of the present invention.

Industrial Applicability

[0101] The present invention is useful, for example, as a passenger boarding bridge that is capable of keeping a suitable contact state between an aircraft and a bumper of a cab even when the aircraft moves upward/downward due to, for example, boarding/disembarking of passengers.

Reference Signs List

- [0102] 10 tunnel unit
- 12 rotunda
- 15 drive column

- 15A lifting/lowering device
- 20 cab
- 21 walkway
- 21A inclinable floor
- 21B bumper
- 25 level detection device
- 25A wheel
- 30 retractable bumper unit
- 31 moving mechanism
- 32 slide plate
- 32a, 32b edge portion of the slide plate
- 34 urging member
- 35 moving member
- 50 control device
- 100 passenger boarding bridge
- 200 aircraft
- 400 passage direction

CLAIMS

1. A passenger boarding bridge comprising:
 - a rotunda connected to a terminal building;
 - a tunnel unit whose proximal end is connected to the rotunda, the tunnel unit being swingable vertically such that a distal end of the tunnel unit is lifted and lowered;
 - a cab provided at the distal end of the tunnel unit; and
 - a lifting/lowering device configured to support the tunnel unit and lift and lower the tunnel unit, wherein
 - the cab includes:
 - a floor serving as a walkway connected to the tunnel unit;
 - a moving member movable in a passage direction of the walkway relative to the floor;
 - a bumper urged in the passage direction relative to the moving member via an urging member; and
 - a moving mechanism configured to move the moving member in the passage direction relative to the floor,
 - the passenger boarding bridge further comprising:
 - a detector configured to detect a contact state between the bumper and the aircraft;
 - and
 - a control device configured to control the moving mechanism when the cab is in a docked state with the aircraft, wherein
 - if the detector detects that the bumper has been brought into a state of being in non-contact with the aircraft, the control device controls the moving mechanism to move the moving member in a direction toward the aircraft, such that the bumper is brought into a state of being in contact with the aircraft with a suitable pressure in a predetermined range; and
 - if the detector detects that the bumper in the state of being in contact with the aircraft with a suitable pressure in the predetermined range has been brought into a state of being in contact with the aircraft with an excessive pressure, the control device controls the moving mechanism to move the moving member in a direction away from the aircraft, such that the bumper is brought into the state of being in contact with the aircraft with a suitable pressure in the predetermined range.
2. The passenger boarding bridge according to claim 1, further comprising a level detection device configured to detect an amount of vertical upward/downward movement of the

aircraft relative to the cab after the cab is docked with the aircraft, wherein

when the cab is in a docked state with the aircraft, the control device controls the lifting/lowering device based on a value outputted from the level detection device, such that the cab follows the upward/downward movement of the aircraft.

3. The passenger boarding bridge according to claim 1 or 2, wherein the detector includes:

a first switch configured to operate such that the first switch is turned on or off in accordance with whether or not the bumper is in a state of being in contact with the aircraft;

a second switch configured to operate such that the second switch is turned on or off in accordance with whether or not the bumper is in a state of being in contact with the aircraft with a pressure greater than or equal to a lower limit value of the predetermined range;

a third switch configured to operate such that the third switch is turned on or off in accordance with whether or not the bumper is in a state of being in contact with the aircraft with a pressure greater than an upper limit value of the predetermined range; and

a contact state determiner configured to:

determine based on an operation state of the first switch whether or not the bumper is in the state of being in non-contact with the aircraft; and

determine based on an operation state of the second switch and an operation state of the third switch whether the bumper is in the state of being in contact with the aircraft with a suitable pressure in the predetermined range or is in the state of being in contact with the aircraft with an excessive pressure.

4. The passenger boarding bridge according to any one of claims 1 to 3, wherein the cab further includes a slide plate including two edge portions that are away from each other in the passage direction,

of the two edge portions, one edge portion is mounted along an upper end of the bumper, and the other edge portion is placed on a surface of the floor, and

the slide plate slides along the surface of the floor in accordance with movement of the bumper.