DESCRIPTION

TITLE OF INVENTION: BUS BAR UNIT, PLUGIN ADAPTER, METHOD FOR PRODUCING PLUGIN-TYPE BREAKER, RAIL, AND RAIL MEMBER

Technical Field

[0001] The present invention relates to a busbar unit, a plug-in adapter, a method of producing a plug-in breaker, a rail, and a rail member, each to configure a distribution board and a switchboard, for example. The present invention firstly relates to a busbar unit provided with, for example, a plurality of busbars to electrically connect a plurality of branch breakers to one main breaker. The present invention secondly relates to a plug-in adapter and a method of producing a plug-in breaker to adapt, for example, a plurality of breakers with different structures to a specific mount of a distribution board and a switchboard. The present invention thirdly relates to a rail and a rail member to attach, for example, an electrical/electronic device, such as a breaker, a terminal block unit, and a sensor, to an object.

Background Art

[0002] 1. Busbar Unit in the Past

For example, a distribution board and a switchboard are provided with one main breaker, a plurality of busbars, and a plurality of branch breakers. The main breaker has a secondary side electrically connected to the plurality of branch breakers via the plurality of busbars. Each of the branch breakers has a secondary side electrically connected to, for example, various loads via indoor wirings. The load refers to a device that operates by consuming power. In each distribution board and switchboard in the recent years, the plurality of busbars configure a collective busbar unit on a mount. The busbar unit is electrically connected to a plurality of plug-in branch breakers. Each plug-in branch breaker is provided with a plug-in terminal, causing any one of the busbars configuring the busbar unit to be inserted.

[0003] For example, JP 2016-208611 A (Patent Document 1) discloses a distribution board including one main breaker, one busbar unit, and a plurality of plug-in branch breakers. Three busbars configuring the busbar unit are stacked at upper, middle, and lower positions above a mount. The busbars at the middle and lower positions are provided with a plurality of branch bars (male terminals). Meanwhile, each branch breaker is provided with three insertion ports corresponding to the respective three busbars. Among the three insertion ports, the two insertion ports at the upper and

middle positions or the two insertion ports at the upper and lower positions store respective plug-in terminals. Into the insertion port at the upper position of the branch breaker, a longitudinally extending side portion of the busbar at the upper position is inserted. The plug-in terminal at the upper position of the branch breaker is thus electrically connected to the busbar at the upper position. Meanwhile, into the insertion port at the middle or lower position of the branch breaker, the branch bar of the busbar at the middle or lower position is inserted. The plug-in terminal at the middle or lower position of the branch breaker is thus electrically connected to the busbar at the middle or lower position.

[0004] 2. Plug-In Breaker in the Past

There are two kinds breakers in the past, including screw breakers and plug-in breakers. The screw breakers include a terminal provided with a threaded hole. Such a screw breaker is thus electrically connected to the busbar unit described above by screwing the terminal to the busbar. Meanwhile, the plug-in breakers include plug-in terminals to insert the busbars. Such a plug-in branch breaker is thus electrically connected to the busbar unit described above by inserting the busbar into the plug-in terminal.

[0005] For example, as disclosed in JP 2006-230134 A (Patent Document 3), there is a plug-in adapter to convert screw breakers to plug-in breakers. Such a plug-in adapter includes a horizontal portion to place a screw breaker and a vertical portion having a plug-in terminal stored therein. The horizontal portion and the vertical portion are designed to adapt to the shape and dimensions of a specific screw breaker. The horizontal portion is configured with a thin plate capable of elastic deformation. The horizontal portion has a front end and a rear end provided with respective locking tabs. Meanwhile, the screw breaker has a front end and a rear end provided with concave locking portions corresponding to the respective locking tabs. Elastic deformation of the horizontal portion allows the locking tab to be locked to the concave locking portion. The screw breaker is thus held by the horizontal portion.

[0006] 3. Rail in the Past

For example, distribution boards and switchboards are configured by combining general purpose products distributed on the market. As the general purpose products, various kinds of breakers and busbars with different structures are sold. Users can assemble distribution boards and switchboards adapted to their purposes by arbitrarily selecting a main breaker, branch breakers, and busbars.

[0007] In order to attach electrical/electronic devices, such as a breaker, a terminal block unit, and a sensor, at predetermined positions in a housing, rails complying with

standards in Japan and overseas are sold. For example, metal rails are sold in shapes and dimensions defined by Japan Industrial Standard (JIS), International Electrotechnical Commission (IEC), German Institute for Standardization (Deutsches Institut fuer Normung e.V.) (DIN), and the like. The electrical/electronic devices are provided with an attachment portion capable of coupling with a rail complying with any of the standards.

[0008] For example, JP 2020-24004 A (Patent Document 4) discloses a distribution board with a configuration where a plurality of breakers in alignment in line are attached in a housing via a DIN rail complying with the standard of JIS-C-2812. JP H02-210776 A (Patent Document 5) discloses a unit terminal block with a configuration where a plurality of terminal block units in alignment in line are attached to a DIN rail.

Prior Art Documents

Patent Documents

[0009] Patent Document 1: JP 2016-208611 A
Patent Document 2: JP 2020-022278 A
Patent Document 3: JP 2006-230134 A
Patent Document 4: JP 2020-24004 A
Patent Document 5: JP H02-210776 A

Disclosure of the Invention

Problems to be solved by the Invention

[0010] 1. Problems in Busbars in the Past

In the distribution board of JP 2016-208611 A described above, electrically connected areas of the busbar unit, that is, the busbar at the upper position and the branch bars of the busbars at the middle and lower positions are exposed outside. Thus, there is a risk of receiving an electric shock by touching any one of the busbar at the upper position or the branch bars of the busbars at the middle and lower positions when a user changes any of the branch breakers.

[0011] To cope with this situation, JP 2020-022278 A (Patent Document 2) discloses a distribution board with a configuration where a plurality of protective covers are attached to the respective busbars configuring the busbar unit. The protective covers cover end surfaces of the busbars and partially expose at least one of the front surfaces or the back surfaces of the busbars.

[0012] However, the distribution board of JP 2020-022278 A has to attach the plurality of protective covers to the respective busbars, causing problems of increasing the

number of components configuring the busbar unit and taking more time and effort to assemble the busbar unit.

[0013] 2. Problems in Plug-In Breaker in the Past

Issue of Interchangeability

As described above, distribution boards and switchboards are configured by combining general purpose products distributed on the market. As the general purpose products, various kinds of breakers and busbars with different structures are sold. Users can assemble a distribution board or a switchboard adapted to their purposes by arbitrarily selecting a main breaker, branch breakers, and busbars.

[0014] The plug-in adapters in the past described above are, however, designed to adapt to the shape and dimensions of a specific breaker. Such a plug-in adapter in the past is thus not capable of being adapted to a plurality of breakers with different structures. That is, the plug-in adapter in the past has a configuration where the locking tab is locked to the concave locking portion to hold a screw breaker in the horizontal portion. The plug-in adapter in the past thus cannot be used for a breaker not provided with a concave locking portion adapted to the locking tab. In addition, the plug-in adapter in the past cannot be used for a breaker not adapted to the dimensions of the horizontal portion.

[0015] Issue of Poor Connection

In the plug-in adapter in the past, the vertical portion and the horizontal portion are configured with separate components and the horizontal portion is configured with a thin plate capable of elastic deformation. Thus, when a busbar is inserted into a plug-in terminal of the plug-in adapter, the vertical portion storing the plug-in terminal is sometimes tilted in a direction opposite to the busbar. The tilt of the vertical portion causes reduction in the amount of busbar insertion into the plug-in terminal and poor electrical connection.

[0016] That is, when the plug-in adapter is moved in the direction of the busbar, the busbar is inserted into the plug-in terminal and the plug-in terminal is expanded upward and downward. In this situation, a reaction force occurs in the direction opposite to the busbar. This reaction force causes an upper portion of the vertical portion to be tilted in the direction opposite to the busbar using a lower portion of the vertical portion as a fulcrum. This causes the reduction in the amount of busbar insertion into the plug-in terminal. There is another case that the busbar is not inserted into the plug-in terminal and slightly contacts with the plug-in terminal. A smaller contact area of the busbar and the plug-in terminal causes an increase in the resistance at the contact point and thus an excessive increase in the temperature of the plug-in terminal.

[0017] 3. Problems in Rail in the Past

The metal rails in the past described above are sold in the length of, for example, 100 mm, 150 mm, 200 mm, 1000 mm, 2000 mm, or the like. Users have to cut the purchased rail into a desired length. It is difficult to cut such a metal rail into a desired length and it takes a lot of time and effort.

[0018] The metal rails in the past are supposed to be cut into a desired length. Thus, the entire length of such a commercially available metal rail is too long for widths of smallest electrical/electronic devices. For example, a single-pole breaker has a width of approximately 25 mm. In contrast, the entire length of a shortest metal rail is 100 mm, which is equivalent to the width of a four-pole breaker. The metal rail with the entire length of 100 mm is too long for a breaker with a width 25 mm. Accordingly, users have no other way but to cut commercially available metal rails in order to obtain a metal rail with a length suitable for the width of a single-pole breaker.

[0019] Moreover, the DIN rail disclosed in JP H02-210776 A has to have the DIN rail with both ends attached to metal fittings in order not to fall the plurality of terminal block units. The two metal fittings cause an increase in the entire length of the unit terminal block.

[0020] 4. Objects of the Present Invention

Firstly, it is an object of the present invention to provide a busbar unit capable of securely preventing an electric shock and capable of greatly reducing the number of components for preventing an electric shock, allowing easy assembly.

[0021] Secondly, it is an object of the present invention to provide a plug-in adapter and a method of producing a plug-in breaker capable of being adapted to a plurality of breakers with different structures and not causing poor electrical connection.

[0022] Thirdly, it is an object of the present invention to provide a rail and a rail member capable of being readily divided into a predetermined length and capable of attaching electrical/electronic devices to various objects.

Means to solve the Problems

[0023] 1. Busbar Unit of the Present Invention

(1) To achieve the above objects, a busbar unit of the present invention includes a plurality of busbars, wherein the busbar unit includes a pair of bar holders configured to hold each of the busbars in a horizontal state at an interval in vertical alignment, each of the bar holders is provided with a plurality of horizontal grooves inside each bar holder at an interval in vertical alignment and each of the grooves has a vertical width corresponding to a thickness of each busbar, each bar holder is provided with an

opening portion leading to the grooves and with a plurality of horizontal protection portions arranged at positions corresponding to the grooves in the opening portion, both outside each bar holder, and each of the protection portions has a vertical width corresponding to the thickness of each busbar, and each busbar has a longitudinally extending side portion to be inserted into the groove, causing an end surface of the side portion of each busbar to face the protection portion and causing a front surface and a back surface of the side portion of each busbar to be exposed in the opening portion.

[0024]

(2) It is preferred that, in the busbar unit of (1) above, each bar holder is provided with at least one vertically extending first wall outside each bar holder, the first wall vertically partitions the opening portion to form a plurality of insertion ports, and each of the insertion ports has a horizontal width allowing insertion of a terminal electrically connected to the side portion of each busbar.

[0025]

(3) It is preferred that, in the busbar unit of (1) above, each bar holder is provided with at least one horizontally extending second wall outside each bar holder, the second wall horizontally partitions the opening portion to form a plurality of insertion ports, and each of the insertion ports has a vertical width allowing insertion of a terminal electrically connected to the side portion of each busbar.

[0026]

(4) It is preferred that, in the busbar unit of (1) above, each bar holder is provided with at least one vertically extending first wall and at least one horizontally extending second wall, both outside each bar holder, the first wall and the second wall vertically and horizontally partition the opening portion to form a plurality of insertion ports, and each of the insertion ports has horizontal and vertical widths allowing insertion of a terminal electrically connected to the side portion of each busbar.

[0027] 2. Plug-In Adapter and Method of Producing Plug-In Breaker

(5) To achieve the above objects, a plug-in adapter of the present invention for fixing a breaker attachable to a rail in predetermined shape and dimensions to a mount and for electrically connecting the breaker to a busbar in a plug-in system, the plug-in adapter includes: an adapter body; a plug-in terminal; and a rail member, wherein the adapter body includes a horizontal portion to have the breaker attached via the rail member and a vertical portion capable of holding the plug-in terminal at a predetermined height and the rail member includes a base portion having a configuration attachable to the horizontal portion of the adapter body and a pair of rail portions in a shape and dimensions attachable to an attachment portion for the rail

provided in the breaker.

[0028]

(6) It is preferred that, in the plug-in adapter of (5) above, the adapter body further includes an abutment portion and the abutment portion protrudes from an upper portion of the vertical portion in a direction of the horizontal portion and abuts on an area adjacent to the vertical portion on an upper surface of the breaker.

[0029]

(7) It is preferred that the plug-in adapter of (5) above further includes a terminal cover configured to cover a gap between the vertical portion of the adapter body and the breaker attached to the horizontal portion via the rail member, wherein the terminal cover includes a vertically extending side cover portion and a top cover portion horizontally protruding from an upper portion of the side cover portion, the side cover portion covers the gap from two lateral sides, and the top cover portion covers the gap from above and abuts on an area adjacent to the vertical portion on the upper surface of the breaker.

[0030]

(8) It is preferred that, in the plug-in adapter of any one of (5) through (7) above, the plug-in terminal is integrally provided with, as a single component, a second terminal electrically connected to the breaker, the vertical portion of the adapter body configures a box to store the plug-in terminal and has a back surface with a vertically extending opening formed to lead the second terminal, and the second terminal is electrically connected to the breaker attached to the horizontal portion via the opening.

[0031]

(9) It is preferred that, in the plug-in adapter of (8) above, the vertical portion of the adapter body is provided with a convex portion protruding in a direction across the opening and the convex portion holds the second terminal at the predetermined height.

[0032]

(10) To achieve the above objects, a first method of producing a plug-in breaker of the present invention, the plug-in breaker being configured with a breaker attachable to a rail in predetermined shape and dimensions and the plug-in adapter of any one of (5) through (9) above, the method includes: attaching the pair of rail portions of the rail member to the attachment portion for the rail provided in the breaker; and attaching the base portion of the rail member attached to the breaker to the horizontal portion of the plug-in adapter.

[0033]

(11) To achieve the above objects, a second method of producing a plug-in breaker

of the present invention, the plug-in breaker being configured with a breaker attachable to a rail in predetermined shape and dimensions and the plug-in adapter of any one of (5) through (9) above, the method includes: attaching the base portion of the rail member to the horizontal portion of the plug-in adapter; and attaching the attachment portion for the rail provided in the breaker to the pair of rail portions of the rail member attached to the horizontal portion of the plug-in adapter.

[0034]

(12) To achieve the above objects, a third method of producing a plug-in breaker of the present invention, the plug-in breaker being configured with a breaker attachable to a rail in predetermined shape and dimensions and the plug-in adapter of (7) above, the method includes: attaching the breaker to the horizontal portion of the plug-in adapter via the rail member; and covering the gap between the vertical portion of the plug-in adapter and the breaker attached to the horizontal portion via the rail member with the terminal cover.

[0035] 3. Rail and Rail Member of the Present Invention

(13) To achieve the above objects, a rail of the present invention for attaching one or more electrical/electronic devices to an object, the rail includes a plurality of rail members integrally molded as a single component from a synthetic resin, wherein the plurality of rail members are arranged in alignment with one direction, two of the rail members adjacent to each other are coupled by a division portion with a thickness capable of being broken by applying an external force, each of the rail members includes a base portion having a fixation portion to allow fixation to the object and a pair of rail portions in a shape and dimensions attachable to an attachment portion for the rail provided in the electrical/electronic devices, and the base portion has an approximately quadrangular outline, the pair of rail portions are integrally molded with two facing sides of the base portion as a single component, and the rail portions of each rail member are arranged in alignment with a longitudinal direction of the rail.

[0036]

(14) It is preferred that, in the rail of (13) above, the fixation portion is a through hole allowing a screw to be inserted.

[0037]

(15) It is preferred that, in the rail of (14) above, the base portion has a first fixation portion to insert the screw from a front surface side of the rail member and a second fixation portion to insert the screw from a back surface side of the rail member.

[0038]

(16) It is preferred that, in the rail of (14) or (15) above, at least one of the fixation

portion of the base portion is configured by partially combining a plurality of circular through holes with different diameters.

[0039]

(17) It is preferred that, in the rail of any one of (13) through (16) above, a third fixation portion as a through hole allowing a screw to be inserted is formed between two of the rail members adjacent to each other.

[0040]

(18) It is preferred that, in the rail of (17) above, the base portion has two side surfaces without the pair of integrally molded rail portions, the two side surfaces being integrally molded with a pair of approximately semicircular depressions as a single component, and the depressions of two of the rail members adjacent to each other form the third fixation portion.

[0041]

(19) It is preferred that, in the rail of any one of (13) through (18) above, at least one of the pair of rail portions has a back surface integrally molded with, as a single component, at least one convex portion to abut on the attachment portion for the rail.

[0042]

(20) To achieve the above objects, a rail member of the present invention for attaching one electrical/electronic device to an object, the rail member being integrally molded from a synthetic resin as a single component in a shape and dimensions corresponding to an attachment portion for a rail provided in the one electrical/electronic device, the rail member includes: a base portion having a fixation portion to allow fixation to the object; and a pair of rail portions attachable to the attachment portion for the rail, wherein the base portion has an approximately quadrangular outline, the pair of rail portions are integrally molded with two facing sides of the base portion as a single component, and at least one of the pair of rail portions has a back surface integrally molded with, as a single component, at least one convex portion to abut on the attachment portion for the rail.

Effects of the Invention

[0043] The busbar unit of the present invention includes the pair of bar holders provided with the plurality of horizontal protection portions. The protection portions are arranged facing the end surfaces of the side portions of the respective busbars. Each protection portion deters a user’s finger from contacting with the end surface of any of the busbars when, for example, the branch breakers are electrically connected to the busbar unit. This allows a user to be securely prevented from receiving an electric

shock. In addition, each protection portion is provided in the pair of bar holders, allowing large reduction in the number of components to prevent an electric shock. Thus, assembly of the busbar unit is facilitated.

[0044] The plug-in adapter of the present invention is configured to be attached to the attachment portion for the rail of the breaker via the rail member. Accordingly, the shape and dimensions of the rail member are adapted to the attachment portion for the rail of the breaker, thereby allowing the plug-in adapter of the present invention to be attached to a plurality of breakers with different structures.

[0045] In the rail of the present invention, the division portion may be broken to readily divide the plurality of rail members manually. It is thus possible to readily obtain a rail with an arbitrary length of a total of the widths of the one or more rail members. In addition, the first through third fixation portions allow electrical/electronic devices formed in the base portion of the rail member to be attached to various objects. Moreover, the rail member of the present invention has the shape and dimensions corresponding to the attachment portion for the rail provided in the one electrical/electronic device. The one rail member thus has an optimum width for smallest electrical/electronic devices.

Brief Description of the Drawings

[0046] Figs. 1 illustrate a distribution board including a busbar unit, a plug-in adapter, a rail, and a rail member according to an embodiment of the present invention. Fig. 1(a) is a perspective view illustrating the distribution board in a state of closing a door of a housing. Fig. 1(b) is a perspective view illustrating the distribution board in a state of opening the door of the housing.

Figs. 2 illustrate a main breaker, a busbar unit, branch breakers, plug-in adapters, busbars, a busbar cover, a rail, and mounts as components of the distribution board stored in the housing. Fig. 2(a) is a perspective view, and Fig. 2(b) is an exploded perspective view.

Figs. 3 illustrate the main breaker, the busbar unit, the branch breakers, plug-in adapters, and curved busbars. Fig. 3(a) is a perspective view, and Fig. 3(b) is a plan view.

Figs. 4 illustrate the busbar unit, the branch breakers, the plug-in adapters, and the mounts. Fig. 4(a) is a perspective view, and Fig. 4(b) is an exploded perspective view.

Figs. 5 illustrate a busbar unit according to a first embodiment of the present invention and mounts. Fig. 5(a) is a perspective view, and Fig. 5(b) is a cross-sectional

view.

Fig. 6 is an exploded perspective view of the busbar unit illustrated in Fig. 5(a).

Fig. 7 is an exploded perspective view illustrating busbars, supporting members, spacers, and stoppers as components of the busbar unit illustrated in Fig. 6.

Figs. 8 illustrate inside the bar holder as a component of the busbar unit. Fig. 8(a) is a side view of the inside, Fig. 8(b) is a perspective view taken from the inside, and Fig. 8(c) is a cross-sectional view of Fig. 8(b).

Figs. 9 illustrate outside the bar holder. Fig. 9(a) is a side view of the outside, Fig. 9(b) is a perspective view taken from the outside, and Fig. 9(c) is a cross-sectional view of Fig. 9(b).

Figs. 10 illustrate a state of assembling the busbars and the bar holder. Fig. 10(a) is a cross-sectional view taken from the inside, and Fig. 10(b) is a cross-sectional view taken from the outside.

Fig. 11(a) is a perspective cross-sectional view illustrating a main part of a busbar unit according to a second embodiment. Fig. 11(b) is a perspective cross-sectional view illustrating a main part of a busbar unit according to a third embodiment.

Fig. 12(a) is a perspective cross-sectional view illustrating a main part of the busbar unit according to the first embodiment. Fig. 12(b) is a perspective cross-sectional view illustrating a main part of the busbar unit according to the second embodiment. Fig. 12(c) is a perspective cross-sectional view illustrating a main part of the busbar unit according to the third embodiment.

Figs. 13 illustrate a plug-in breaker configured with a plug-in adapter according to the first embodiment of the present invention and a branch breaker. Fig. 13(a) is a perspective view, and Fig. 13(b) is a side view.

Figs. 14 illustrate an adapter body of the plug-in adapter. Fig. 14(a) is an exploded perspective view, and Fig. 14(b) is a perspective view taken from a bottom surface side.

Figs. 15 illustrate two adapter bodies and a mount. Fig. 15(a) is a perspective view, and Fig. 15(b) is a plan view.

Figs. 16(a) and 16(b) are perspective views to illustrate movement of a second terminal in the plug-in adapter of the first embodiment.

Fig. 17 is a perspective view illustrating an adapter body of a plug-in adapter according to the second embodiment.

Fig. 18 is a perspective cross-sectional view illustrating a state of coupling the busbar unit, the plug-in adapter, the branch breaker, and the mount with each other.

Fig. 19 is a side cross-sectional view illustrating state of coupling the busbar

unit, the plug-in adapter, the branch breaker, and the mount with each other.

Fig. 20(a) is a side view illustrating the branch breaker. Fig. 20(b) is a side view illustrating the branch breaker attached to a rail member.

Fig. 21(a) is a perspective view illustrating the branch breaker and the rail member. Fig. 21(b) is a perspective view of the branch breaker and the rail member taken from a bottom surface side. Fig. 21(c) is a bottom view illustrating a state of coupling the branch breaker and the rail member.

Figs. 22 illustrate the adapter body and the rail member configuring the plug-in adapter. Fig. 22(a) is a perspective view, and Fig. 22(b) is a plan view.

Fig. 23(a) is a partially enlarged view illustrating a horizontal portion of the adapter body. Fig. 23(b) is a perspective view illustrating the rail member. Fig. 23(c) is a plan view illustrating a through hole and a first locking portion provided in the horizontal portion of the adapter body. Fig. 23(d) is a plan view illustrating a state before locking the first locking portion to the rail member. Fig. 23(e) is a plan view illustrating a state of locking the first locking portion to the rail member.

Figs. 24(a), 24(b), and 24(c) are perspective views illustrating respective steps of a method of producing the plug-in breaker according to the first embodiment.

Figs. 25(a), 25(b), and 25(c) are perspective views illustrating respective steps of a method of producing the plug-in breaker according to the second embodiment.

Fig. 26 is an exploded perspective view illustrating a plug-in adapter according to the third embodiment.

Fig. 27(a), 27(b), 27(c), and 27(d) are perspective views illustrating respective steps of a method of producing the plug-in breaker according to the third embodiment.

Fig. 28(a), 28(b), and 28(c) are side views illustrating the steps of Figs. 27(b) through 27(c) in more detail.

Fig. 29(a) is a side view illustrating the plug-in adapter according to the third embodiment and the branch breaker. Fig. 29(b) is a side view illustrating the plug-in adapter, the branch breaker, and the terminal cover.

Fig. 30(a) is a perspective view of the terminal cover taken from a front surface side. Fig. 30(b) is a perspective view of the terminal cover taken from a back surface side.

Fig. 31 is a perspective view illustrating a rail member according to an embodiment of the present invention.

Fig. 32(a) is a plan view illustrating the rail member. Fig. 32(b) is a bottom view illustrating the rail member. Fig. 32(c) is a perspective view of the rail member taken from a bottom surface side.

Fig. 33 is a perspective view illustrating a rail according to an embodiment of the present invention.

Fig. 34 is a plan view illustrating the rail.

Fig. 35 is a perspective view illustrating a plug-in breaker configured with branch breakers and plug-in adapters provided with rails.

Fig. 36 is a perspective view illustrating a configuration for fixing the branch breakers to the mount via the rail.

Figs. 37 illustrate a plug-in breaker configured with a plug-in adapter, a branch breaker, and an accessory. Fig. 37(a) is a perspective view, and Fig. 37(b) is a plan view.

Fig. 38(a) is a perspective view illustrating a busbar unit and a mount. Fig. 38(b) is a perspective view illustrating a state of electrically connecting a plurality of plug-in breakers, each provided with the accessory, to the busbar unit.

Figs. 39 illustrate a plurality of plug-in breakers provided with a busbar unit according to a fourth embodiment of the present invention, a mount, and accessories. Fig. 39(a) is a perspective view illustrating a state of not electrically connecting some of the plug-in breakers to the busbar unit. Fig. 39(b) is a perspective view illustrating a state of electrically connecting the plurality of plug-in breakers to the busbar unit.

Figs. 40 illustrate a bar holder configuring the busbar unit according to the fourth embodiment of the present invention. Fig. 40(a) is a perspective view, and Fig. 40(b) is a front view.

Figs. 41 illustrate another bar holder configuring the busbar unit according to a fifth embodiment of the present invention. Fig. 41(a) is a perspective view, and Fig. 41(b) is a front view.

Figs. 42 illustrate a bar holder configuring the busbar unit according to a sixth embodiment of the present invention. Fig. 42(a) is a perspective view, and Fig. 42(b) is a front view.

Figs. 43 illustrate a bar holder configuring a busbar unit according to a seventh embodiment of the present invention. Fig. 43(a) is a perspective view, and Fig. 43(b) is a front view.

Figs. 44 illustrate busbar units provided with two sets of bar holders, and two sets of mounts. Fig. 44(a) is a perspective view illustrating a state of not electrically connecting plug-in breakers to the busbar units. Fig. 44(b) is a perspective view illustrating a state of electrically connecting a plurality of plug-in breakers, each provided with an accessory, to the busbar units.

Fig. 45 is a front view illustrating first and second bar holders configuring a

busbar unit according to an eighth embodiment of the present invention.

Fig. 46(a) is a perspective view illustrating the busbar unit according to the eighth embodiment of the present invention and a mount. Fig. 46(b) is a perspective view illustrating a state of electrically connecting a plurality of plug-in breakers, each provided with an accessory, to the busbar unit.

Fig. 47 is a front view illustrating first and second bar holders configuring a busbar unit according to a ninth embodiment of the present invention.

Modes for Carrying Out the Invention

[0047] A description is given below to embodiments of a distribution board including a busbar unit, a plug-in adapter, a rail and a rail member of the present invention with reference to the drawings.

[0048] 1. Distribution Board

Fig. 1(a) illustrates an outward appearance of a distribution board 1 in the present embodiment. All components of the distribution board 1 are stored in a housing 10 having a door 10a. The door 10a is openably and closably attached to the housing 10 via hinges, not shown. The door 10a is provided with a handle 10b to open and close the door 10a. The handle 10b may be provided with a lock mechanism. As illustrated in Fig. 1(b), in the housing 10, electrical/electronic devices, such as a main breaker 2, a busbar unit 3, and a plurality of branch breakers 4, configuring the distribution board 1 are fixed via frames 11 and first through fourth mounts 12 through 15.

[0049] Figs. 2(a), 2(b) and Figs. 3(a), 3(b) illustrate the components of the distribution board 1 in more detail. The two frames 11 are vertically arranged at a predetermined interval from each other. The two frames 11 are coupled to each of the first through fourth mounts 12 through 15. The first through fourth mounts 12 through 15 are horizontally arranged at intervals from each other. To the first and second mounts 12 and 13, the main breaker 2 is fixed. To the fourth mount 15, the busbar unit 3 and a plurality of plug-in adapters 5 are fixed. Each of the plug-in adapters 5 is attached to the branch breaker 4 via a rail member 60 or a rail 6 described later.

[0050] The main breaker 2 has three poles, the respective poles being electrically connected to the primary side of busbars 30 of the busbar unit 3 via curved busbars 70. The curved busbars 70 and the busbars 30 are covered with a busbar cover 80 illustrated in Figs. 2(a) and 2(b). The busbar cover 80 is fixed to the curved busbars 70. Each busbar 30 of the busbar unit 3 has a secondary side electrically connected to the plurality of branch breakers 4 via the plug-in adapters 5. Each branch breaker 4 has a

secondary side electrically connected to various loads via, for example, indoor wirings. To the main breaker 2, the utility power is supplied from outdoor wirings. The utility power is supplied to the plurality of branch breakers 4 via the curved busbars 70, the busbars 30, and the plug-in adapters 5 and distributed to the loads electrically connected to the indoor wirings.

[0051] As illustrated in Fig. 4(a), the busbar unit 3, the plurality of plug-in adapters 5, and the plurality of branch breakers 4 are fixed to the fourth mount 15 to configure a collective unit. In addition, as illustrated in Fig. 4(b), the branch breakers 4 attached to the plug-in adapters 5 configure a plug-in breaker. Via the rail member 60 illustrated in Fig. 31, each plug-in adapter 5 is attached to one of the branch breakers 4 to configure the one plug-in breaker. Meanwhile, via the rail 6 formed by integrating a plurality of rail members 60 as a single component illustrated in Fig. 33, the plurality of plug-in adapters 5 are attached to the plurality of branch breakers 4 to allow configuration of a collective unit of a plurality of plug-in breakers. The busbar unit 3 and the fourth mount 15 configure a base for attaching the plurality of plug-in breakers or a collective unit of them.

[0052] 2. Busbar Unit

As illustrated in Figs. 5(a) and 5(b), the busbar unit 3 is configured to hold the four busbars 30, each in a horizontal state, at an interval in vertical alignment. As illustrated in Fig. 6 and Fig. 7, the busbar unit 3 is configured with bar holders 31, supporting members 32, spacers 33, stoppers 34, and a top cover 35. To electrically insulate the four busbars 30, the bar holders 31, the supporting members 32, the spacers 33, the stoppers 34, and the top cover 35 are formed from a synthetic resin as an insulator.

[0053] The four busbars 30 are supported by the two supporting members 32 attached to the fourth mount 15. The two supporting members 32 are inserted through two quadrangular holes provided on the secondary side of the busbars 30. Between the four busbars 30, the six spacers 33 are placed. Each spacer 33 has a hollow with a quadrangular cross section. Into the hollow of the spacer 33, the supporting member 32 are inserted. The supporting member 32 inserted through the busbars 30 and the spacers 33 has a distal end on which the stopper 34 is mounted. Each stopper 34 has an upper portion provided with a pair of tabs. The stoppers 34 causes the busbars 30 and the spacers 33 to be fixed to the supporting members 32. The four busbars 30 fixed to the supporting members 32 have both side portions covered with the pair of bar holders 31. Each bar holder 31 has a bottom surface provided with two locking portions 317 illustrated in Figs. 8(a) and 8(b). The locking portions 317 are locked to

first locking holes 15a in the fourth mount 15. Meanwhile, each bar holder 31 has an upper surface provided with two fitting portions 316. The tabs of the stoppers 34 and the fitting portions 316 of the bar holders 31 are coupled to holes in the top cover 35.

[0054] Moreover, as illustrated in Fig. 6, each of the four fitting portions 316 provided in the pair of bar holders 31 is provided with a through hole. When the four fitting portions 316 are coupled to the top cover 35, the two fitting portions 316 provided in one of the pair of bar holders 31 face the other two as illustrated in Fig. 5(a). The pair of bar holders 31 are coupled by inserting pins, not shown, into the through holes in the two facing fitting portions 316.

[0055] In addition to this, as illustrated in Fig. 6, each bar holder 31 has an outer side surface provided with a pair of fixation portions 318 at the lowest positions in two end portions. Each fixation portion 318 has a through hole to insert a screw, not shown, formed at the center. When the two locking portions 317 of each bar holder 31 are locked to the first locking holes 15a in the fourth mount 15, the through holes in the fixation portions 318 overlap threaded holes 15d in the fourth mount 15. The bar holder 31 is fixed to the fourth mount 15 by screwing the screws inserted through the through holes in the fixation portions 318 with the threaded holes 15d.

[0056] 2.1 Busbar Unit according to First Embodiment

The configuration of the busbar unit 3 according to the first embodiment is described with reference to Figs. 8(a) through 10(b). The busbar unit 3 in the first embodiment is characterized in the configuration of the bar holders 31.

[0057] Fig. 8(a), 8(b), and 8(c) illustrate the internal configuration of each bar holder 31. Inside the bar holder 31, four horizontal grooves 311 are provided at an interval in vertical alignment. Each of the four grooves 311 has a vertical width corresponding to the thickness of the busbars 30. Into the four grooves 311, the respective side portions of the busbars 30 are inserted. The four grooves 311 lead to an opening portion 312 (refer to Figs. 9(a) through 9(c)) outside the bar holder 31.

[0058] In addition, around the four grooves 311 inside the bar holder 31, a large number of holes are provided. All the holes lead to the opening portion 312 outside the bar holder 31. The large number of holes in the bar holder 31 suppress an increase in the temperature of the busbar 30 due to the passage of electric current.

[0059] Fig. 9(a), 9(b), and 9(c) illustrate the external configuration of each bar holder 31. Outside the bar holder 31, the opening portion 312 leading to the four grooves 311 described above is provided. The opening portion 312 is provided with five vertically extending first walls 314 and three horizontally extending second walls 315. The first walls 314 and the second walls 315 vertically and horizontally partition the opening

portion 312 to form a plurality of insertion ports 312a. Each of the insertion ports 312a has horizontal and vertical widths allowing insertion of a plug-in terminal 51 (refer to Fig. 12(a)). At positions corresponding to the grooves 311 in the respective insertion ports 312a, horizontal protection portions 313 are provided. Each protection portion 313 has a vertical width corresponding to the thickness of the busbar 30.

[0060] As illustrated in Figs. 10(a) and 10(b), each busbar 30 has a longitudinally extending side portion to be inserted into the groove 311, causing an end surface of the side portion of the busbar 30 to face the protection portion 313 and a front surface and a back surface of the side portion of the busbar 30 to be exposed in the insertion port 312a.

[0061] It should be noted that, in the case that the grooves 311 are capable of firmly holding the four busbars 30 provided in the pair of bar holders 31, the supporting members 32, the spacers 33, and the stoppers 34 illustrated in Fig. 7 may be omitted from the configuration of the busbar unit 3.

[0062] 2.2 Busbar Unit according to Second Embodiment

Fig. 11(a) illustrates the configuration of one of bar holders 31 of a busbar unit 3 according to the second embodiment. The bar holder 31 may have a configuration where the opening portion 312 is provided only with a plurality of vertically extending first walls 314. The plurality of first walls 314 form vertically ranging insertion ports 312a. Each of the vertically ranging insertion ports 312a has horizontal and vertical widths allowing insertion of a plug-in terminal 51 (refer to Fig. 12(b)). At positions corresponding to the grooves 311 in the respective insertion ports 312a, horizontal protection portions 313 are provided. Each busbar 30 has a longitudinally extending side portion to be inserted into the groove 311, causing an end surface of the side portion of the busbar 30 to face the protection portion 313 and a front surface and a back surface of the side portion of the busbar 30 to be exposed in the insertion port 312a.

[0063] 2.3 Busbar Unit according to Third Embodiment

Fig. 11(b) illustrates the configuration of one of bar holders 31 of a busbar unit 3 according to the third embodiment. The bar holder 31 may have a configuration where the opening portion 312 is provided only with a plurality of horizontally extending second walls 315. The plurality of second walls 315 form horizontally ranging insertion ports 312a. Each of the horizontally ranging insertion ports 312a has horizontal and vertical widths allowing insertion of a plug-in terminal 51 (refer to Fig. 12(c)). At positions corresponding to the grooves 311 of the respective insertion ports 312a, horizontal protection portions 313 are provided. Each busbar 30 has a

longitudinally extending side portion to be inserted into the groove 311, causing an end surface of the side portion of the busbar 30 to face the protection portion 313 and a front surface and a back surface of the side portion of the busbar 30 to be exposed in the insertion port 312a.

[0064] 2.4 Action and Effects of Busbar Unit

Any of the busbar units 3 in the first through third embodiments described above includes the pair of bar holders 31 provided with the plurality of horizontal protection portions 313. Each protection portion 313 is arranged facing the end surface of a side portion of each busbar 30. Each protection portion 313 deters a user's finger from contacting with the end surface of the side portion of the busbar 30 when, for example, a plug-in breaker (refer to Figs. 13(a) and 13(b)) is electrically connected to the busbar unit 3. This allows a user to be securely prevented from receiving an electric shock. In addition, each protection portion 313 is provided in the pair of bar holders 31, allowing large reduction in the number of components to prevent an electric shock. Thus, assembly of the busbar unit 3 is facilitated.

[0065] As illustrated in Figs. 12(a) and 12(b), the first wall portions 314 of each bar holder 31 prevent short circuits between the two horizontally aligned plug-in terminals 51. Meanwhile, as illustrated in Figs. 12(a) and 12(c), the second wall portions 315 of each bar holder 31 prevent short circuits between the two vertically aligned plug-in terminals. In particular, the bar holder 31 illustrated in Fig. 12(a) is capable of individually insulating each of the plurality of plug-in terminals 51 with the first wall portions 314 and the second wall portions 315. Thus, short circuits are securely prevented between all the vertically and horizontally aligned plug-in terminals 51.

[0066] It should be noted that, in Figs. 12(a) and 12(b), the interval between the plurality of first wall portions 314 is a dimension corresponding to the width of each plug-in terminal 51 although the interval is not limited to this example. For example, the interval between the plurality of first wall portions 314 may be a dimension corresponding to a multiple of the width of each plug-in terminal 51. Meanwhile, the interval between the plurality of second wall portions 315 is preferably a dimension corresponding to the height of each plug-in terminal 51 although the interval is not limited to this example. For example, the interval between the plurality of second wall portions 315 may be a dimension corresponding to a multiple of the height of each plug-in terminal 51.

[0067] 3. Plug-In Adapter

Figs. 13(a) and 13(b) illustrate a plug-in breaker configured with the plug-in adapter 5 according to the first embodiment and the branch breaker 4.

[0068] 3.1 Uses of Plug-In Adapter

Firstly, the plug-in adapter 5 in the present embodiment is used to convert screw breakers to a plug-in breaker. Such a screw breaker includes poles electrically connected to the busbar 30 by fastening a screw. Building of the plug-in terminal 51 electrically connected to the poles of the screw breaker in the plug-in adapter 5 allows conversion of the screw breaker to the plug-in breaker.

[0069] Secondly, the plug-in adapter 5 in the present embodiment is used to adapt various breakers in different shapes and dimensions to the distribution board 1 in the present embodiment. Specifically, the plug-in adapter 5 is capable of changing general purpose breakers distributed on the market to a plug-in breaker adapted to the busbar unit 3 and the fourth mount 15 illustrated in Fig. 5(a).

[0070] 3.2 Configuration of Plug-In Adapter

The plug-in adapter 5 in the present embodiment is mainly configured with an adapter body 50 and a rail member 60 illustrated in Figs. 13(a) and 13(b). Figs. 14(a) and 14(b) illustrate the configuration of the adapter body 50. In the adapter body 50, the plug-in terminal 51 illustrated in Fig. 14(a) is built.

[0071] 3.3 Adapter Body

As illustrated in Fig. 14(a), the adapter body 50 is formed from a synthetic resin and has an outward appearance in an approximately L shape. The adapter body 50 includes a horizontal portion 510, a vertical portion 520, an abutment portion 530, and a fixation portion 540 described below.

[0072] 3.3.1 Horizontal Portion

To the horizontal portion 510, the branch breaker 4 is attached via the rail member 60 illustrated in Fig. 13(a). The horizontal portion 510 has an upper surface provided with a through hole 511 and a first locking portion 512 for fixing the rail member 60. How the through hole 511 and the first locking portion 512 fix the rail member 60 is detailed later with reference to Figs. 22(a) through 24(c). As illustrated in Fig. 14(b), the inside of the horizontal portion 510 is hollow, and the through hole 511 penetrates a plate configuring the upper surface of the horizontal portion 510. The first locking portion 512 is a projection integrally molded with the upper surface of the horizontal portion 510 as a single component and has a tab protruding in the direction of the fixation portion 540 in Fig. 14(a).

[0073] As illustrated in Fig. 14(b), the horizontal portion 510 has two longitudinally extending bottom sides integrally molded with four second locking portions 513 as a single component. Each two facing second locking portions 513 have respective inward protruding tabs. The second locking portions 513 are for attaching the adapter

body 50 to the fourth mount 15 illustrated in Fig. 7. The four second locking portions 513 are locked to four second locking holes 15b in the fourth mount 15.

[0074] As illustrated in Fig. 7, each second locking hole 15b in the fourth mount 15 has a configuration where a wide width area continues to a narrow width area. As illustrated in Figs. 15(a) and 15(b), to attach the adapter body 50 to the fourth mount 15, at first, the four second locking portions 513 of the horizontal portion 510 are inserted into the wide width areas of the four second locking holes 15b in the fourth mount 15. Then, the adapter body 50 is slid on the fourth mount 15 to lock the four second locking portions 513 to the narrow width areas of the four second locking holes 15b.

[0075] As illustrated in Fig. 14(a), the horizontal portion 510 has an end surface integrally molded with a third locking portion 514, as a single component, for locking the fixation portion 540. The third locking portion 514 has two vertically parallel rails that protrude outward and extend vertically. The two rails of the third locking portion 514 are locked to a first locking portion 541 formed on the back surface of the fixation portion 540.

[0076] 3.3.2 Fixation Portion

Meanwhile, the fixation portion 540 is integrally molded with a second locking portion 542, as a single component, to be locked to any one of third locking holes 15c in the fourth mount 15 illustrated in Fig. 7. The second locking portion 542 of the fixation portion 540 has a tab to be inserted into the third locking hole 15c and to engage with an edge portion of the third locking hole 15c. As illustrated in Figs. 15(a) and 15(b), the second locking portion 542 of the fixation portion 540 is locked to the third locking hole 15c in the fourth mount 15 to limit movement of the adapter body 50 on the fourth mount 15. Thus, the above-described locking of the second locking portions 513 of the horizontal portion 510 to the second locking holes 15b in the fourth mount 15 is maintained.

[0077] 3.3.3 Vertical Portion

The vertical portion 520, together with a cover portion 521, configures a hollow box to store the plug-in terminal 51. In this situation, assuming that the vertical portion 520 is a vertically extending rectangular parallelepiped box, a surface of the vertical portion 520 on the opposite side to the horizontal portion 510 is defined as a “front surface” and a surface of the vertical portion 520 on the side of the horizontal portion 510 is defined as a “back surface”.

[0078] The vertical portion 520 has a front surface integrally molded with four storage portions, as a single component, protruding on the opposite side to the horizontal portion 510. Each storage portion is configured with a pair of upper and lower

horizontal wall portions. The upper and lower wall portions configuring the storage portion covers the approximately C-shaped plug-in terminal 51 and allows access to an inner surface of the plug-in terminal 51. The four storage portions are different in height positions from each other. The plug-in terminal 51 is stored in any one of the four storage portions by mounting and demounting the cover portion 521 to and from the vertical portion 520. The plug-in terminal 51 stored in the storage portion is held at a height corresponding to any one of the four busbars 30 illustrated in Fig. 10(b).

[0079] The vertical portion 520 has a back surface with a vertically extending opening 522 formed in an approximately rectangular shape. As illustrated in Fig. 14(a), the plug-in terminal 51 is integrally provided with a plug shaped second terminal 51a as a single component. When the plug-in terminal 51 is stored in any one of the four storage portions of the vertical portion 520, the second terminal 51a protrudes from the opening 522 to the horizontal portion 510 side. The second terminal 51a is electrically connected to the branch breaker 4 attached to the horizontal portion 510 via the opening 522.

[0080] 3.3.4 Abutment Portion

The vertical portion 520 has an upper portion provided with the abutment portion 530. The abutment portion 530 protrudes from the upper portion of the vertical portion 520 in the direction of the horizontal portion 510. As illustrated in Figs. 13(a) and 13(b), the branch breaker 4 has an upper surface on which two step portions are formed. The abutment portion 530 has a shape corresponding to the step portion 4a adjacent to the vertical portion 520 among the two step portions of the branch breakers 4. The abutment portion 530 configures an approximately quadrangular box without a bottom surface. That is, the abutment portion 530 has an approximately quadrangular upper wall and three side walls extending downward from three sides of the upper wall (refer to Fig. 14(b)). The three side walls of the abutment portion 530 have end surfaces abutting on a horizontal surface of the step portion 4a of the branch breaker 4 attached to the horizontal portion 510. Moreover, among the three side walls of the abutment portion 530, the side wall on the opposite side to the vertical portion 520 abuts on a vertical surface of the step portion 4a of the branch breaker 4.

[0081] The approximately quadrangular upper wall of the abutment portion 530 is provided with an oval hole. In the case that the branch breaker 4 is a screw breaker, it is possible to access a screw for moving a terminal of the branch breaker 4 upward and downward via the oval hole in the abutment portion 530. It is also possible to electrically connect a measuring instrument, such as an ammeter, to the screw of the branch breaker 4 via the oval hole in the abutment portion 530 and to check the state of

the passage of electric current in the branch breaker 4.

[0082] 3.4 Plug-In Adapter according to Second Embodiment

As described above, the vertical portion 520 of the adapter body 50 illustrated in Fig. 14(a) has the back surface with the opening 522 formed to lead the second terminal 51a. The reason why the opening 522 is in the vertically extending approximately rectangular shape is to adapt the plug-in adapter 5 in the present embodiment to various breakers in different shapes and dimensions. That is, the height position of a terminal of the breaker electrically connected to the second terminal 51a varies depending on the breaker. The vertically extending approximately rectangular opening 522 allows vertical adjustment of the height position of the second terminal 51a in accordance with terminals of various breakers.

[0083] However, the vertically extending approximately rectangular opening 522 as illustrated in Figs. 16(a) and 16(b) sometimes causes the second terminal 51a to move downward in the opening 522 under its own weight (refer to the arrow in Fig. 16(b)). Thus, to prevent downward movement of the second terminal 51a, the second terminal 51a has to be electrically connected to the terminal of the branch breaker 4 while supporting the second terminal 51a.

[0084] Fig. 17 illustrates an adapter body 50 of a plug-in adapter 5 according to the second embodiment. As illustrated in Fig. 17, the vertical portion 520 of the adapter body 50 is preferably provided with a convex portion 523 protruding in the direction across the opening 522. Such a convex portion 523 causes the second terminal 51a protruding from the approximately rectangular opening 522 to be held at a predetermined height optimum for the terminal of the branch breaker 4.

[0085] 3.5 State of Coupling of Plug-In Adapter

Figs. 18 and 19 illustrate a state of coupling the busbar unit 3, the plug-in adapter 5, the branch breaker 4, and the fourth mount 15 with each other. The branch breaker 4 is attached to the horizontal portion 510 of the adapter body 50 via the rail member 60. Although not shown, the terminal of the branch breaker 4 is electrically connected to the second terminal 51a protruding from the vertical portion 520 of the adapter body 50. The plug-in adapter 5 and the branch breaker 4 thus configure a plug-in breaker adapted to the busbar unit 3.

[0086] This plug-in breaker is attached to the fourth mount 15 by locking the four second locking portions 513 provided in the horizontal portion 510 of the adapter body 50 to the four second locking holes 15b in the fourth mount 15. In this situation, the plug-in terminal 51 stored in the vertical portion 520 of the adapter body 50 is electrically connected to any one of the busbars 30 of the busbar unit 3. That is, a side

portion of the busbar 30 is inserted into the approximately C-shaped plug-in terminal 51. The plug-in terminal 51 thus contacts with the front surface and the back surface of the side portion of the busbar 30.

[0087] In this situation, when the busbar 30 is inserted into the plug-in terminal 51, a reaction force occurs in the direction opposite to the busbar 30. However, this reaction force does not cause the vertical portion 520 of the adapter body 50 to be tilted in the direction opposite to the busbar 30. The vertical portion 520 is prevented from being tilted by abutting the abutment portion 530 on the step portion 4a of the branch breaker 4. Thus, the amount of insertion of the busbar 30 into the plug-in terminal 51 is sufficiently secured and the busbar 30 is well electrically connected to the plug-in terminal 51.

[0088] Finally, the second locking portion 542 of the fixation portion 540 is locked to the third locking hole 15c in the fourth mount 15. Thus, the locking of the horizontal portion 510 of the adapter body 50 to the fourth mount 15 is maintained and the electrical connection between the plug-in terminal 51 and the busbar 30 is maintained.

[0089] 3.6 Attachment Portion for Branch Breaker and Rail Member

The characteristic configuration of the rail member 60 according to the present embodiment is detailed later. In this section, a description is given to an attachment portion 40 for the branch breaker 4 and then an overview of the rail member 60.

[0090] As illustrated in Fig. 20(a), the branch breaker 4 is a single-pole breaker and is provided with the attachment portion 40 on the bottom surface. The attachment portion 40 has a configuration capable of coupling with metal rails in shapes and dimensions defined by, for example, Japan Industrial Standard (JIS), International Electrotechnical Commission (IEC), German Institute for Standardization (Deutsches Institut fuer Normung e.V.) (DIN), and the like.

[0091] The attachment portion 40 for the branch breaker 4 is configured with a first locking portion 41, a second locking portion 42, and a concave portion 43. The first and second locking portions 41 and 42 are provided at both ends of the concave portion 43 to face each other. The first locking portion 41 is integrally molded with the bottom surface of the branch breaker 4 as a single component. Meanwhile, the second locking portion 42 includes a slider 42a capable of moving in the longitudinal direction of the concave portion 43. The slider 42a is biased in the direction of the first locking portion 41 by a spring, not shown. The metal rail complying with the standards in Japan and overseas is fit into the concave portion 43 and locked by the first and second locking portions 41 and 42.

[0092] As illustrated in Fig. 20(b), the rail member 60 in the present embodiment has a

configuration in accordance with the single-pole branch breaker 4. Each rail member 60 is capable of attaching one of the branch breakers 4 to one of the adapter bodies 50. Each rail member 60 is attached to the attachment portion 40 for the branch breaker 4.

[0093] As illustrated in Figs. 21(a), 21(b), and 21(c), the rail member 60 is configured with a base portion 61 and a pair of rail portions 62 integrally molded from a synthetic resin as a single component. The base portion 61 has a configuration attachable to the horizontal portion 510 of the adapter body 50 described above. Meanwhile, each rail portion 62 has a shape and dimensions attachable to the attachment portion 40 for the branch breaker 4. As illustrated in Fig. 23(b), the rail member 60 has a longitudinal width W1 and a height H in dimensions, for example, in accordance with the JIS, IEC, or DIN standards. The rail member 60 in accordance with the JIS and IEC standards has the longitudinal width W1 of 35 mm and the height H of 7.5 mm. The rail member 60 in accordance with the single-pole branch breaker 4 has a transverse width W2 of 25 mm.

[0094] 3.7 Fixation of Rail Member to Adapter Body

Figs. 22(a) and 22(b) and Figs. 23(a) through 23(c) illustrate the configuration and steps for fixing the rail member 60 to the horizontal portion 510 of the adapter body 50. As described above, the horizontal portion 510 of the adapter body 50 is provided with the through hole 511 and the first locking portion 512. Through the through hole 511, a screw 90 (refer to Fig. 24(b)) is inserted from the back side of the horizontal portion 510. The first locking portion 512 is a projection integrally molded with the upper surface of the horizontal portion 510 as a single component and has a tab protruding in the direction of the fixation portion 540 in Fig. 23(a).

[0095] As illustrated in Fig. 23(b), the base portion 61 of the rail member 60 is provided with a first fixation portion 611 and a second fixation portion 612.

[0096] The first fixation portion 611 is a through hole allowing the screw 90 (refer to Fig. 36) to be inserted from the front surface side of the base portion 61. The first fixation portion 611 is configured by partially combining a plurality of circular through holes with different diameters. For example, the first fixation portion 611 illustrated in Fig. 23(b) is configured by partially combining three circular through holes with different diameters. This allows the screw 90 with a variable diameter to be inserted through the first fixation portion 611.

[0097] In addition, the entire length of the first fixation portion 611 is longer than the entire length of the first locking portion 512 of the horizontal portion 510 illustrated in Fig. 23(a). This allows the rail member 60 to slide on the horizontal portion 510 in a state where the first locking portion 512 is inserted into the first fixation portion 611.

The end portion, on the opposite side to the second fixation portion 612, of the first fixation portion 611 is provided with a depression capable of locking to the tab of the first locking portion 512.

[0098] The second fixation portion 612 is a cylinder integrally molded with the base portion 61 as a single component and corresponds to the through hole 511 in the horizontal portion 510 illustrated in Fig. 23(c). The second fixation portion 612 has an inner diameter approximately equal to the inner diameter of the through hole 511. The screw 90 (refer to Fig. 24(b)) inserted through the through hole 511 from the back side of the horizontal portion 510 is screwed to the inner surface of the second fixation portion 612.

[0099] The rail member 60 is fixed to the horizontal portion 510 of the adapter body 50 through the steps illustrated in Figs. 23(c), 23(d), and 23(e). At first, as illustrated in Figs. 23(c) and 23(d), the rail member 60 is placed on the horizontal portion 510 while inserting the first locking portion 512 into the first fixation portion 611. Then, as illustrated in Figs. 23(d) and 23(e), the rail member 60 is slid on the horizontal portion 510 in the direction of the second fixation portion 612. Thus, the tab of the first locking portion 512 is locked to the end portion of the first fixation portion 611. In this situation, the second fixation portion 612 coincides with the through hole 511. This allows the screw 90 inserted through the through hole 511 from the back side of the horizontal portion 510 to be screwed to the inner surface of the second fixation portion 612. The screwing of the screw 90 does not allow the rail member 60 to slide on the horizontal portion 510 to maintain the locking of the first locking portion 512 to the first fixation portion 611. In other words, the first fixation portion 611 is fixed to the horizontal portion 510. Then, the branch breaker 4 illustrated in Fig. 21(a) is attached to the rail member 60 fixed to the horizontal portion 510. The plug-in breaker configured with the branch breaker 4 and the plug-in adapter 5 is thus produced.

[0100] 3.8 Method of Producing Plug-In Breaker according to First Embodiment

Figs. 24(a) through 24(c) illustrate the respective steps of the method of producing the plug-in breaker according to the first embodiment. At first, as illustrated in Fig. 24(a), the rail member 60 is attached to the attachment portion 40 for the branch breaker 4. Then, as illustrated in Fig. 24(b), the first locking portion 512 of the horizontal portion 510 is locked to the first fixation portion 611 of the rail member 60 while the branch breaker 4 is electrically connected to the second terminal 51a of the adapter body 50. Then, the screw 90 inserted through the through hole 511 from the back side of the horizontal portion 510 is screwed to the inner surface of the second fixation portion 612. Thus, the branch breaker 4 is attached to the adapter body 50 and

the plug-in breaker illustrated in Fig. 24(c) is produced.

[0101] 3.9 Method of Producing Plug-In Breaker according to Second Embodiment

Figs. 25(a) through 25(c) illustrate the respective steps of the method of producing the plug-in breaker according to the second embodiment. At first, as illustrated in Fig. 25(a), the rail member 60 is attached to the attachment portion 40 for the branch breaker 4. Then, as illustrated in Fig. 25(b), the cover portion 521 and the plug-in terminal 51 are separated from the vertical portion 520 of the adapter body 50 in advance. The second terminal 51a of the plug-in terminal 51 is then electrically connected to the branch breaker 4. Then, the first locking portion 512 of the horizontal portion 510 is locked to the first fixation portion 611 of the rail member 60 while the plug-in terminal 51 is stored in any of the storage portion of the vertical portion 520. Then, the screw 90 inserted through the through hole 511 from the back side of the horizontal portion 510 is screwed to the inner surface of the second fixation portion 612. Thus, the branch breaker 4 is attached to the adapter body 50 and the plug-in breaker illustrated in Fig. 25(c) is produced.

[0102] 3.10 Plug-In Adapter according to Third Embodiment

Fig. 26 illustrates a plug-in adapter 5 according to the third embodiment. The plug-in adapter 5 illustrated in Fig. 26 is configured with a rail member 600 and a first locking portion 512, which are different from the rail members 60 and the first locking portions 512 in the first and second embodiments.

[0103] The rail member 600 has a base portion 61 and a pair of rail portions 62 formed by bending one sheet metal. Similar to the rail members 60 described above in the first and second embodiments, the rail member 600 has a shape and dimensions in accordance with the standards in Japan and overseas. That is, the rail member 600 has a longitudinal width W1 and a height H in dimensions, for example, in accordance with the JIS, IEC, or DIN standards. In addition, the rail member 600 has a transverse width W2 in accordance with the attachment portion 40 for the single-pole branch breaker 4.

[0104] The rail member 600 has a base portion 61 provided with two circular through holes. Meanwhile, the first locking portion 512 of the adapter body 50 is provided with two threaded holes corresponding to the respective through holes in the base portion 61. Two screws 90 are inserted through the respective through holes in the base portion 61 and screwed to the two threaded holes in the first locking portion 512, thereby fixing the rail member 600 to the horizontal portion 510 of the adapter body 50.

[0105] In this situation, the vertical portion 520 of the plug-in adapter 5 according to the third embodiment is not provided with any of the abutment portion 530 (refer to

Figs. 16(a) and 17) in the first and second embodiments described above. In the plug-in adapter 5 according to the third embodiment, a terminal cover 52 illustrated in Fig. 27(d) is provided with a top cover portion 52b. The top cover portion 52b abuts on the step portion 4a of the branch breaker 4 to prevent the vertical portion 520 from being tilted. In other words, the top cover portion 52b exhibits action and effects identical to those of the abutment portions 530 described above in the first and second embodiments. The terminal cover 52 is detailed later with reference to Figs. 29(b), 30(a), and 30(b).

[0106] 3.11 Method of Producing Plug-In Breaker according to Third Embodiment

Figs. 27(a) through 29(b) illustrate the respective steps of the method of producing the plug-in breaker according to the third embodiment. In the present embodiment, a description is given to the method of producing the plug-in breaker configured with the plug-in adapter 5 described above in the third embodiment, the branch breaker 4, and the terminal cover 52.

[0107] As illustrated in Fig. 27(a), the rail member 60 is not attached to the attachment portion 40 for the branch breaker 4. As illustrated in Fig. 27(b), the rail member 600 is fixed to the horizontal portion 510 of the adapter body 50 in advance by the two screws 90 (refer to Fig. 26).

[0108] As illustrated in Figs. 28(a) and 28(b), the attachment portion 40 for the branch breaker 4 is attached to the rail member 600 while the branch breaker 4 is electrically connected to the second terminal 51a of the adapter body 50. In this procedure, at first, the branch breaker 4 is tilted in the direction of the vertical portion 520 to lock the first locking portion 41 of the attachment portion 40 to one of the rail portions 62 of the rail member 600. Then, using the first locking portion 41 and the one rail portion 62 as a fulcrum, the branch breaker 4 is slightly rotated in the direction opposite to the vertical portion 520. Thus, the second locking portion 42 of the attachment portion 40 is locked to the other rail portion 62 of the rail member 600. That is, the second locking portion 42 abuts on the other rail portion 62 to slide once in the direction opposite to the other rail portion 62. Then, when passing the other rail portion 62, the second locking portion 42 again slides in the direction of the other rail portion 62 to be locked to the other rail portion 62. Thus, as illustrated in Figs. 27(c) and 28(c), the branch breaker 4 is attached to the adapter body 50. Finally, the terminal cover 52 is attached to a gap G between the branch breaker 4 and the vertical portion 520. Thus, the plug-in breaker illustrated in Fig. 27(d) is produced.

[0109] 3.12 Terminal Cover

As illustrated in Fig. 28(b), in order to lock the first locking portion 41 of the

attachment portion 40 to the one rail portion 62 of the rail member 600, the branch breaker 4 has to be tilted in the direction of the vertical portion 520. Thus, as illustrated in Figs. 28(c) and 29(a), the gap G is left between the branch breaker 4 attached to the rail member 600 and the vertical portion 520. The gap G is a space provided to tilt the branch breaker 4 in the direction of the vertical portion 520. In the gap G, the second terminal 51a is turned out to be exposed. To cope with this situation, in the method of producing the plug-in breaker of the third embodiment described above, the gap G is covered with the terminal cover 52 illustrated in Fig. 29(b).

[0110] Figs. 30(a) and 30(b) illustrate the configuration of the terminal cover 52. The terminal cover 52 is configured with a side cover portion 52a and the top cover portion 52b. The side cover portion 52a and the top cover portion 52b are integrally molded as a single component from a synthetic resin as an insulator. The side cover portion 52a is formed from a vertically extending wall. The wall forming the side cover portion 52a has a slit 52c formed to avoid the second terminal 51a in the gap G. The top cover portion 52b horizontally protrudes in the horizontal direction from an upper portion of the side cover portion 52a. The side cover portion 52a covers the gap G from two lateral sides. The top cover portion 52b covers the gap G from above and abuts on the step portion 4a of the branch breaker 4.

[0111] The top cover portion 52b has a configuration identical to that of the abutment portion 530 illustrated in Figs. 14(a) and 14(b). That is, the top cover portion 52b has a shape corresponding to the step portion 4a adjacent to the vertical portion 520 among the two step portions of the branch breaker 4. The top cover portion 52b configures an approximately quadrangular box without a bottom surface. That is, the top cover portion 52b has an approximately quadrangular upper wall and three side walls extending downward from three sides of the upper wall. The three side walls of the top cover portion 52b have end surfaces abutting on the horizontal surface of the step portion 4a of the branch breaker 4 attached to the horizontal portion 510. Moreover, among the three side walls of the top cover portion 52b, the side wall on the opposite side to the vertical portion 520 abuts on the vertical surface of the step portion 4a of the branch breaker 4.

[0112] The approximately quadrangular upper wall of the top cover portion 52b is provided with an oval hole. In the case that the branch breaker 4 is a screw breaker, it is possible to access the screw for moving a terminal of the branch breaker 4 upward and downward via the oval hole in the top cover portion 52b. It is also possible to electrically connect a measuring instrument, such as an ammeter, to the screw of the

branch breaker 4 via the oval hole in the top cover portion 52b and to check the state of the passage of electric current in the branch breaker 4.

[0113] 3.13 Action and Effects of Plug-In Adapter

Any of the plug-in adapter 5 in the first through third embodiments described above is configured to be attached to the attachment portion for the rail of a general purpose breaker via the rail member 60 or 600. Accordingly, adapting the shape and dimensions of the rail member 60 or 600 to the attachment portion for the rail of the breaker allows attachment of a plurality of breakers with different structures to the plug-in adapter 5 in the present embodiment.

[0114] 4. Rail Member

Then, the rail member 60 according to the present embodiment is described with reference to Fig. 31 and Figs. 32(a) through 32(c).

[0115] As illustrated in Fig. 31, the rail member 60 is configured with a base portion 61 and a pair of rail portions 62. The base portion 61 and the pair of rail portions 62 are integrally molded as a single component from a synthetic resin as an insulator. The base portion 61 has an approximately quadrangular outline. The pair of rail portions 62 are integrally molded with two facing sides of the base portion 61 as a single component.

[0116] 4.1 Base Portion

As illustrated in Figs. 31 and 32(a), the base portion 61 has a first fixation portion 611, a second fixation portion 612, and third fixation portions 613 to allow fixation to an object. The “object” in this context includes, for example, the adapter body 50 of the plug-in adapter 5 illustrated in Fig. 18, the fourth mount 15 illustrated in Fig. 36, and the like.

[0117] As described above, the first fixation portion 611 is a through hole allowing the screw 90 (refer to Fig. 36) to be inserted from the front surface side of the base portion 61. The first fixation portion 611 is configured by partially combining a plurality of circular through holes with different diameters. This allows the screw 90 with a variable diameter to be inserted through the first fixation portion 611. The entire length of the first fixation portion 611 is longer than the entire length of the first locking portion 512 of the horizontal portion 510 illustrated in Fig. 23(a). The rail member 60 is thus slidable on the horizontal portion 510 while the first locking portion 512 is inserted into the first fixation portion 611. The first fixation portion 611 has an end portion on the opposite side to the second fixation portion 612 provided with a depression capable of locking to the tab of the first locking portion 512.

[0118] As described above, the second fixation portion 612 is a cylinder integrally

molded with the base portion 61 as a single component. The second fixation portion 612 allows screwing to the screw 90 (refer to Fig. 24(b)) inserted from the back surface side of the base portion 61. For example, the second fixation portion 612 corresponds to the through hole 511 in the horizontal portion 510 illustrated in Fig. 23(c). The second fixation portion 612 has an inner diameter approximately equal to the inner diameter of the through hole 511. The screw 90 (refer to Fig. 24(b)) inserted through the through hole 511 from the back side of the horizontal portion 510 is screwed to an inner surface of the second fixation portion 612.

[0119] The third fixation portions 613 are semicircular depressions respectively formed on the other two side surfaces of the base portion 61 without the pair of integrally molded rail portions 62. For example, as illustrated in Fig. 34, when the plurality of rail members 60 are arranged in alignment with one direction, the third fixation portions 613 of two adjacent rail members 60 form an approximately circular through hole.

[0120] 4.2 One Pair of Rail Portions

The pair of rail portions 62 have a shape and dimensions attachable to the attachment portion for a rail provided in an electrical/electronic device. The "electrical/electronic device" in this context includes, for example, the branch breaker 4 illustrated in Figs. 21(a) through 21(c) and the like. The "attachment portion for a rail" includes, for example, the attachment portion 40 for the branch breaker 4 capable of coupling with metal rails in shapes and dimensions defined by JIS, IEC, DIN, and the like. As illustrated in Fig. 23(b), each rail portion 62 has a transverse width W3 and a height H in dimensions, for example, in accordance with the JIS, IEC, or DIN standards. The rail portion 62 has a longitudinal width W2 of the length in accordance with the attachment portion 40 for the single-pole branch breaker 4.

[0121] As illustrated in Figs. 32(b) and 32(c), the pair of rail portions 62 have back surfaces integrally molded with a first convex portion 621, second convex portions 622, a third convex portion 623, and a fourth convex portion 624. For example, general purpose breakers distributed on the market are provided with attachment portions including locking portions in various configurations. At least one of the first through fourth convex portions 621 through 624 adapts to such a locking portion in various configurations.

[0122] The first through fourth convex portions 621 through 624 are respectively described below with reference to Figs. 32(b) and 32(c). It should be noted that Figs. 21(b) and 21(c) illustrate the structure of the attachment portion 40 for the branch breaker 4, the first locking portion 41, and the second locking portion 42 in the

description below.

[0123] The first convex portion 621 is provided on one of the rail portions 62 corresponding to the second locking portion 42. The first convex portion 621 is configured with five semi-columnar projections. The five projections configuring the first convex portion 621 have the same length as the transverse width W3 (refer to Fig. 23(b)) of each rail portion 62. Such first convex portion 621 contacts with the back surface of the second locking portion 42 to limit lateral movement of the branch breaker 4.

[0124] The second convex portions 622 are provided on both rail portions 62 corresponding to the first and second locking portions 41 and 42. The second convex portions 622 are configured with a pair of projections with a trapezoidal cross section. The pair of projections configuring the second convex portions 622 have the same length as the transverse width W3 (refer to Fig. 23(b)) of each rail portion 62. Such a second convex portion 622 contacts with the back surfaces of the first and second locking portions 41 and 42 to limit the lateral movement of the branch breaker 4. It should be noted that the pair of projections configuring the second convex portions 622 may have a configuration to abut on the side surfaces of the first and second locking portions 41 and 42 to limit the lateral movement of the branch breaker 4.

[0125] The third convex portion 623 is provided on the other rail portion 62 corresponding to the first locking portion 41. The third convex portion 623 has a width to fit inside a notch portion 41a of the first locking portion 41. Such a third convex portion 623 is fit into the first locking portion 41 to limit the lateral movement of the branch breaker 4.

[0126] The fourth convex portion 624 is integrally molded with the third convex portion 623 as a single component. The fourth convex portion 624 is a projection configured with a hemispherical top portion and a semi-columnar body portion. Some of the general purpose breakers have a locking portion provided with a concave portion adapted to the shape of the fourth convex portion 624. The fourth convex portion 624 fits the concave portion of the locking portion to limit the lateral movement of the branch breaker 4.

[0127] 5. Rail

Then, the rail 6 according to the present embodiment is described with reference to Figs. 33 through 36.

[0128] As illustrated in Figs. 33 and 34, the rail 6 is configured with the plurality of rail members 60 integrally molded as a single component from a synthetic resin. The rail members 60 are arranged in alignment with one direction. Two of the rail

members 60 adjacent to each other are coupled to by a first division portion 6a and a second division portion 6b, each with a thickness capable of being broken by applying an external force. The respective rail portions 62 of each rail member 60 are arranged in alignment with the longitudinal direction of the rail 6.

[0129] As illustrated in Fig. 33, the first division portion 6a is a thin wall formed at the boundary between two of the rail members 60. Meanwhile, as illustrated in Fig. 34, the second division portion 6b is a small rectangular piece formed in each third fixation portion 613 (semicircular depression) of two of the rail members 60 adjacent to each other. The second division portions 6b are integrally molded with the first division portion 6a as a single component in the third fixation portions 613.

[0130] Application of an external force by a user allows the first and second division portions 6a and 6b to be readily separated from the two rail members 60. Meanwhile, as long as an external force is not applied by a user, the first and second division portions 6a and 6b maintain the state of coupling the two rail members 60. A user may fold the rail 6 into two, for example, by placing any one of the first division portions 6a illustrated in Fig. 34 at the center. Thus, the rail 6 is divided into two and the user can obtain the rail 6 with an arbitrary length configured with an arbitrary number of rail members 60. The user is also allowed to divide the one rail member 60 placed at the end of the rail 6 illustrated in Fig. 34.

[0131] Such a division method allows a user to obtain the rail 6 with an optimum length in accordance with the number and size of an electrical/electronic device to be attached to an object. For example, as illustrated in Fig. 35, in the case that the electrical/electronic devices are the single-pole branch breakers 4, the user obtains the rail 6 configured with four of the rail members 60. This rail 6 is fixed to four of the adapter bodies 50 to configure a four-pole plug-in adapter 5. To the four-pole plug-in adapter 5, four of the branch breakers 4 may be attached. The four-pole plug-in breaker is thus configured. The four branch breakers 4 and the four adapter bodies 50 illustrated in Fig. 35 are coupled by the rail 6 to allow them to be handled as one plug-in breaker.

[0132] As illustrated in Fig. 36, a plurality of the branch breakers 4 may be directly attached to the fourth mount 15 via the rail 6. For example, the rail 6 illustrated in Fig. 36 is configured with six of the rail members 60. The rail 6 is fixed to the fourth mount 15 with six screws 90 inserted through the first fixation portions 611 of the respective rail members 60. To the rail 6, six of the branch breakers 4 are attached.

[0133] 5.1 Action and Effects of Rail and Rail Member

In the rail 6 of the present embodiment, the plurality of rail members 60 may

be readily manually divided by breaking the first and second division portions 6a and 6b. Thus, the rail 6 with an arbitrary length of a total of the width of one or more of the rail members 60 may be readily obtained. The first through third fixation portions 611, 612, and 613 formed in the base portion 61 of the rail member 60 allow attachment of electrical/electronic devices to various objects. Moreover, the rail member 60 in the present embodiment has a shape and dimensions corresponding to the attachment portion for the rail provided in one of the electrical/electronic devices. Thus, each rail member 60 has a width W2 optimum for a smallest electrical/electronic device.

[0134] 6. Busbar Unit Adapted to Accessory of Branch Breaker

Figs. 37(a) and 37(b) illustrate a plug-in breaker configured with the branch breaker 4, the plug-in adapter 5, and an accessory 1000. In recent years, various kinds of accessory 1000 are prepared for such a general purpose branch breaker 4. Examples of the accessory 1000 include an alarm switch, an assistant switch, a shunt trip, and the like. The alarm switch electrically displays that the branch breaker 4 is in the tripped state. The assistant switch electrically displays the state of turning on/off the branch breaker 4. The shunt trip causes the branch breaker 4 to be in the tripped state by remote control. As illustrated in Figs. 37(a) and 37(b), the accessory 1000 has an external form in common with the branch breaker 4 and is mounted on a side surface of the branch breaker 4.

[0135] 6.1 Problem in Busbar Unit caused by Accessory

Fig. 38(a) illustrates the busbar unit 3 and the mount 15. As described above, outside each bar holder 31 configuring the busbar unit 3, the six vertically extending opening portions 312 are provided adjacent to each other. Each of the six opening portions 312 is partitioned by the vertical first walls 314 and the horizontal second walls 315. Thus, outside the bar holders 31, the plurality of insertion ports 312a are formed in a matrix.

[0136] However, as illustrated in Fig. 38(b), in the case that the accessory 1000 is mounted on a side surface of each branch breaker 4, there is a problem that the accessories 1000 block the opening portions 312 (the plurality of vertically aligned insertion ports 312a) of the bar holder 31. For example, in the bar holder 31 illustrated in Fig. 38(b), the accessories 1000 block three out of the six opening portions 312. The busbar unit 3 illustrated in Fig. 38(b) is provided with the six opening portions 312 and is thus originally allowed to be electrically connected to six plug-in breakers. However, since the accessories 1000 block the three opening portions 312, only three plug-in breakers are allowed to be electrically connected to the busbar unit 3. Such a problem is caused by providing the plurality of opening portions 312 of each bar holder

31 adjacent to each other.

[0137] 6.2 Busbar Unit according to Fourth Embodiment

A busbar unit 3 according to the fourth embodiment is described below with reference to Figs. 39(a), 39(b), 40(a), and 40(b). It should be noted that, in Figs. 39(a), 39(b), 40(a), and 40(b), the identical reference signs are given to the configuration identical to that of the busbar units 3 according to the first through third embodiments described above to omit the detailed description.

[0138] Fig. 39(a) illustrates the busbar unit 3 according to the fourth embodiment, the branch breakers 4, the accessories 1000, the plug-in adapters 5, and the mount 15. The branch breakers 4 are mounted on the plug-in adapters 5 to configure plug-in breakers adapted to the busbar unit 3. On the left side surface of each branch breaker 4, the accessory 1000 is mounted. Each accessory 1000 has a horizontal width 1/2 of the horizontal width of each branch breaker 4.

[0139] As illustrated in Fig. 39(a), outside bar holders 3100 configuring the busbar unit 3, a plurality of opening portions 312 and a plurality of wall surfaces 3110 are alternately provided. In other words, the opening portions 312 and the wall surfaces 3110 are adjacent to each other. Figs. 40(a) and 40(b) mainly illustrate the external configuration of the outside of one of the bar holders 3100. Each opening portion 312 has a horizontal width approximately identical to the horizontal width of each plug-in breaker (each branch breaker 4 and each plug-in adapter 5). Meanwhile, the wall surfaces 3110 are vertically extending rectangular flat surfaces. Each wall surface 3110 has a horizontal width 3/4 of the horizontal width of each opening portion 312. Each of the wall surfaces 3110 forms a spacer region between two of the opening portions 312. Each spacer region is a rectangular parallelepiped space with the height and the width identical to those of each wall surface 3110.

[0140] Fig. 39(b) illustrates a state of coupling the busbar unit 3 according to the fourth embodiment, the branch breakers 4, the accessories 1000, the plug-in adapters 5, and the fourth mount 15 with each other. The plug-in terminal 51 (refer to Fig. 14(a)) of each plug-in breaker is inserted into any one of the vertically aligned insertion ports 312a in the opening portions 312. Thus, the plug-in terminal 51 is electrically connected to any one of the busbars 30. When the plug-in terminal 51 of each plug-in breaker is inserted into the insertion port 312a, the accessory 1000 mounted on each branch breaker 4 faces the wall surface 3110. That is, the accessories 1000 fit within the spacer regions formed by the wall surfaces 3110. Thus, all the opening portions 312 (the plurality of vertically aligned insertion ports 312a) of the bar holders 3100 are allowed to be used for electrical connection of the plug-in breakers without being

blocked by the accessories 1000.

[0141] In this example, the wall surfaces 3110 are made from the insulator same as the material constituting the bar holders 3100. In addition, the wall surfaces 3110 physically interrupt the busbars 30 inserted inside the bar holders 3100. Moreover, each wall surface 3110 has a horizontal width narrower than the horizontal width of each branch breaker 4 and each plug-in adapter 5. These configurations do not allow a user to electrically connect the plug-in terminals 51 of the plug-in breakers to the busbars 30 at the positions of the wall surfaces 3110. As a result, the plug-in terminals 51 of the plug-in breakers are securely inserted into the insertion ports 312a of the opening portions 312 and electrically connected to the busbars 30.

[0142] 6.3 Busbar Unit according to Fifth Embodiment

Figs. 41(a) and 41(b) illustrate a bar holder 3100 configuring a busbar unit 3 according to the fifth embodiment. The bar holder 3100 is provided with two wall surfaces 3110. Each wall surface 3110 has a horizontal width identical to the horizontal width of each opening portion 312 and two times the horizontal width of each accessory 1000. Such a wall surface 3110 allows facing two of the adjacent accessories 1000. The two adjacent accessories 1000 fit within a spacer region formed by the wall surface 3110.

[0143] Specifically, into the opening portion 312 on the left of the wall portion 3110, the plug-in terminal 51 of a first plug-in breaker is inserted. On the right side surface of the branch breaker 4 configuring the first plug-in breaker, a first accessory 1000 is mounted. Meanwhile, into the opening portion 312 on the right of the wall portion 3110, the plug-in terminal 51 of a second plug-in breaker is inserted. On the left side surface of the branch breaker 4 configuring the second plug-in breaker, a second accessory 1000 is mounted. The first and second accessories 1000 face the wall portion 3110 in the state of being adjacent to each other. That is, the first and second accessories 1000 fit within the spacer region formed by the wall surface 3110. Thus, all the opening portions 312 (the plurality of vertically aligned insertion ports 312a) of the bar holder 3100 are allowed to be used for electrical connection of the plug-in breakers without being blocked by the accessories 1000.

[0144] 6.4 Busbar Unit according to Sixth Embodiment

Figs. 42(a) and 42(b) illustrate a bar holder 3100 configuring a busbar unit 3 according to the sixth embodiment. Outside the bar holder 3100, a plurality of opening portions 312 and a plurality of openings 3120 are alternately provided. In other words, the opening portions 312 and the openings 3120 are adjacent to each other. The openings 3120 are formed by two first walls 314 provided at a certain interval.

Each opening 3120 has a horizontal width 3/4 of the horizontal width of each opening portion 312. Each of the openings 3120 forms a spacer region between two of the opening portions 312. Each spacer region is a rectangular parallelepiped space with the height and the width identical to those of each opening 3120.

[0145] Similar to the busbar unit 3 according to the fourth embodiment described above, the plug-in terminal 51 of each plug-in breaker is inserted into any one of the vertically aligned insertion ports 312a in each opening portion 312. Thus, the plug-in terminal 51 is electrically connected to any one of the busbars 30. When the plug-in terminal 51 of each plug-in breaker is inserted into the insertion port 312a, the accessory 1000 mounted on each branch breaker 4 faces the opening 3120. That is, the accessories 1000 fit within the spacer regions formed by the openings 3120. Thus, all the opening portions 312 (the plurality of vertically aligned insertion ports 312a) of the bar holders 3100 are allowed to be used for electrical connection of the plug-in breakers without being blocked by the accessories 1000.

[0146] In this example, each opening 3120 has a horizontal width narrower than the horizontal width of each plug-in breaker. This configuration does not allow a user to insert the plug-in terminals 51 of the plug-in breakers into the openings 3120. As a result, the plug-in terminals 51 of the plug-in breakers are securely inserted into the insertion ports 312a of the opening portions 312 and electrically connected to the busbars 30.

[0147] 6.5 Busbar Unit according to Seventh Embodiment

Fig. 43(a) and 43(b) illustrate a bar holder 3100 configuring a busbar unit 3 according to the seventh embodiment. Similar to the sixth embodiment described above, outside the bar holder 3100, a plurality of opening portions 312 and a plurality of openings 3120 are alternately provided. Different from the sixth embodiment, the internal space of each opening 3120 in the seventh embodiment is uniformly partitioned by three second walls 315. Each of the four internal spaces partitioned by the second walls 315 is provided with a horizontal protection portion 313 at the center. Each of the four protection portions 313 is at a position corresponding to the respective groove 311 and has a vertical width corresponding to the thickness of each busbar 30.

[0148] The second walls 315 and the protection portions 313 deter a user’s finger from contacting with the end surface of the side portion of any of the busbars 30 when a plug-in breaker is electrically connected to the busbar unit 3. This allows a user to be securely prevented from receiving an electric shock.

[0149] 6.6 Problem in Busbar Unit caused by Two or more Sets of Bar Holders

Fig. 44(a) illustrates a busbar unit 3 provided with two sets of bar holders

3100. The busbar unit 3 in Fig. 44(a) is configured with components two times those of the busbar unit 3 illustrated in Fig. 39(a). It should be noted that the number of busbars 30 is same and the length of the busbars 30 is different.

[0150] In the busbar unit 3 illustrated in Fig. 44(a), the two sets of bar holders 3100 are arranged horizontally adjacent to each other. Thus, as illustrated in Fig. 44(b), one of the opening portions 316 at the boundary between the first bar holder 3100 and the second bar holder 3100 is blocked by the accessory 1000 and is not allowed to be used for electrical connection of the plug-in breaker.

[0151] 6.7 Busbar Unit according to Eighth Embodiment

Fig. 45 illustrates first and second bar holders 3100 configuring a busbar unit 3 according to the eighth embodiment. Each of the first and second bar holders 3100 has a left side surface and a right side surface, both provided with respective vertically extending rod spacers 3130. The spacers 3130 are supported on the respective left side surfaces and right side surfaces of the first and second bar holders 3100 by a plurality of fragile support portions 3131. The combined horizontal width of one of the spacers 3130 and one of the support portions 3131 is 1/3 of the horizontal width of each opening portion 312.

[0152] As illustrated in Fig. 46(a), the first and second bar holders 3100 configuring the busbar unit 3 are arranged in horizontal alignment. At the boundary between the first and second bar holders 3100, two of the spacers 3130 are adjacent to each other. The two spacers 3130 and the plurality of support portions 3131 form a spacer region 2/3 the horizontal width of each opening portion 312. The spacer region is a rectangular parallelepiped space with a height and a width identical to the height of the two spacers 3130 and the combined width of the two spacers 3130 and the plurality of support portions 3131.

[0153] As illustrated in Fig. 46(b), the accessory 1000 of the plug-in breaker at the boundary between the first and second bar holders 3100 faces the two adjacent spacers 3130. That is, this accessory 1000 fits within the spacer region formed by the two spacers 3130 and the plurality of support portions 3131. Thus, all the opening portions 312 (the plurality of vertically aligned insertion ports 312a) of the bar holders 3100 are allowed to be used for electrical connection of the plug-in breakers without being blocked by the accessories 1000.

[0154] In Fig. 46(a), the spacer 3130 on the left side surface and the spacer 3130 on the right side surface, both not at the boundary between the first and second bar holders 3100, may be removed from the bar holders 3100. The plurality of fragile support portions 3131 may be readily manually broken. Accordingly, a user can readily

remove these spacers 3130 from the bar holders 3100.

[0155] 6.8 Busbar Unit according to Ninth Embodiment

Fig. 47 illustrates first and second bar holders 3100 configuring a busbar unit 3 according to the ninth embodiment. Each of the first and second bar holders 3100 has a left side surface provided with a vertically extending plate spacer 3140. The spacers 3140 are supported on the respective left side surfaces of the first and second bar holders 3100 by a plurality of fragile support portions 3141. The combined horizontal width of one of the spacers 3140 and one of the support portions 3141 is 3/4 of the horizontal width of each opening portion 312.

[0156] At the boundary between the first and second bar holders 3100, one of the spacers 3140 and the plurality of support portions 3141 form a spacer region 3/4 the horizontal width of each opening portion 312. Although not shown, the accessory 1000 of the plug-in breaker at the boundary between the first and second bar holders 3100 faces one of the spacers 3140. That is, this accessory 1000 fits within the spacer region formed by the one spacer 3140. Thus, all the opening portions 312 (the plurality of vertically aligned insertion ports 312a) of the bar holders 3100 are allowed to be used for electrical connection of the plug-in breakers without being blocked by the accessories 1000.

[0157] 6.9 Others

The configurations of the wall surfaces 3110, the openings 3120, and the spacers 3130, 3140 described above are not limited to the fourth through ninth embodiments described above. For example, the numbers and positions of the wall surfaces 3110 and the openings 3120 provided outside the bar holders 3100 are not particularly limited. The configuration may be provided with at least one wall surface 3110 and opening 3120 adjacent to the opening portion 312 outside each bar holder 3100. The configuration may also be provided with a plurality of wall surfaces 3110 and openings 3120 adjacent to the outside of each bar holder 3100.

Description of Reference Numerals

[0158]

1	Distribution Board
10	Housing
10a	Door
10b	Handle
11	Frame
12	First Mount

13	Second Mount
14	Third Mount
15	Fourth Mount
15a	First Locking Hole
15b	Second Locking Hole
15c	Third Locking Hole
15d	Threaded Hole
2	Main Breaker
3	Busbar Unit
30	Busbar
31	Bar Holder
311	Groove
312	Opening Portion
312a	Insertion Port
313	Protection Portion
314	First Wall
315	Second Wall
316	Fitting Portion
317	Locking Portion
318	Fixation Portion
32	Supporting Member
33	Spacer
34	Stopper
35	Top Cover
35a	Locking Hole
35b	Fitting Hole
4	Branch Breaker
4a	Step Portion
40	Attachment Portion
41	First Locking Portion
41a	Notch Portion
42	Second Locking Portion
42a	Slider
43	Concave Portion
5	Plug-In Adapter
50	Adapter Body

510	Horizontal Portion
511	Through Hole
512	First Locking Portion
513	Second Locking Portion
514	Third Locking Portion
520	Vertical Portion
521	Cover Portion
522	Opening
523	Convex Portion
530	Abutment Portion
540	Fixation Portion
541	First Locking Portion
542	Second Locking Portion
51	Plug-In Terminal
51a	Second Terminal
52	Terminal Cover
52a	Side Cover Portion
52b	Top Cover Portion
52c	Slit
52d	Opening
6	Rail
6a	First Division Portion
6b	Second Division Portion
60, 600	Rail Member
61	Base Portion
611	First Fixation Portion
612	Second Fixation Portion
613	Third Fixation Portion
62	Rail Portion
621	First Convex Portion
622	Second Convex Portion
623	Third Convex Portion
624	Fourth Convex Portion
70	Curved Busbar
80	Busbar Cover
90	Screw

G	Gap
1000	Accessory
3100	Bar Holder
3110	Wall Surface (Spacer Region)
3120	Opening (Spacer Region)
3130	Spacer (Spacer Region)
3131	Support Portion
3140	Spacer (Spacer Region)
3141	Support Portion

CLAIMS

1. A busbar unit, comprising a plurality of busbars, wherein

the busbar unit includes a pair of bar holders configured to hold each of the busbars in a horizontal state at an interval in vertical alignment,

each of the bar holders is provided with a plurality of horizontal grooves inside each bar holder at an interval in vertical alignment and each of the grooves has a vertical width corresponding to a thickness of each busbar,

each bar holder is provided with an opening portion leading to the grooves and with a plurality of horizontal protection portions arranged at positions corresponding to the grooves in the opening portion, both outside each bar holder, and each of the protection portions has a vertical width corresponding to the thickness of each busbar, and

each busbar has a longitudinally extending side portion to be inserted into the groove, causing an end portion of the side portion of each busbar to face the protection portion and causing a front surface and a back surface of the side portion of each busbar to be exposed in the opening portion.

2. The busbar unit according to claim 1, wherein each bar holder is provided with at least one vertically extending first wall outside each bar holder, the first wall vertically partitions the opening portion to form a plurality of insertion ports, and each of the insertion ports has a horizontal width allowing insertion of a terminal electrically connected to the side portion of each busbar.

3. The busbar unit according to claim 1, wherein each bar holder is provided with at least one horizontally extending second wall outside each bar holder, the second wall horizontally partitions the opening portion to form a plurality of insertion ports, and each of the insertion ports has a vertical width allowing insertion of a terminal electrically connected to the side portion of each busbar.

4. The busbar unit according to claim 1, wherein each bar holder is provided with at least one vertically extending first wall and at least one horizontally extending second wall, both outside each bar holder, the first wall and the second wall vertically and horizontally partition the opening portion to form a plurality of insertion ports, and each of the insertion ports has horizontal and vertical widths allowing insertion of a terminal electrically connected to the side portion of each busbar.

5. A plug-in adapter for fixing a breaker attachable to a rail in predetermined shape and dimensions to a mount and for electrically connecting the breaker to a busbar in a plug-in system, the plug-in adapter comprising:

an adapter body; a plug-in terminal; and a rail member, wherein

the adapter body includes a horizontal portion to have the breaker attached via the rail member and a vertical portion capable of holding the plug-in terminal at a predetermined height and

the rail member includes a base portion having a configuration attachable to the horizontal portion of the adapter body and a pair of rail portions in a shape and dimensions attachable to an attachment portion for the rail provided in the breaker.

6. The plug-in adapter according to claim 5, wherein

the adapter body further includes an abutment portion and

the abutment portion protrudes from an upper portion of the vertical portion in a direction of the horizontal portion and abuts on an area adjacent to the vertical portion on an upper surface of the breaker.

7. The plug-in adapter according to claim 5, further comprising a terminal cover configured to cover a gap between the vertical portion of the adapter body and the breaker attached to the horizontal portion via the rail member, wherein

the terminal cover includes a vertically extending side cover portion and a top cover portion horizontally protruding from an upper portion of the side cover portion,

the side cover portion covers the gap from two lateral sides, and

the top cover portion covers the gap from above and abuts on an area adjacent to the vertical portion on the upper surface of the breaker.

8. The plug-in adapter according to any one of claims 5 through 7, wherein

the plug-in terminal is integrally provided with, as a single component, a second terminal electrically connected to the breaker,

the vertical portion of the adapter body configures a box to store the plug-in terminal and has a back surface with a vertically extending opening formed to lead the second terminal, and

the second terminal is electrically connected to the breaker attached to the horizontal portion via the opening.

9. The plug-in adapter according to claim 8, wherein the vertical portion of the adapter body is provided with a convex portion protruding in a direction across the opening and the convex portion holds the second terminal at the predetermined height.

10. A method of producing a plug-in breaker configured with a breaker attachable to a rail in predetermined shape and dimensions and the plug-in adapter according to any one of claims 5 through 9, the method comprising:

attaching the pair of rail portions of the rail member to the attachment portion for the rail provided in the breaker; and

attaching the base portion of the rail member attached to the breaker to the horizontal portion of the plug-in adapter.

11. A method of producing a plug-in breaker configured with a breaker attachable to a rail in predetermined shape and dimensions and the plug-in adapter according to any one of claims 5 through 9, the method comprising:

attaching the base portion of the rail member to the horizontal portion of the plug-in adapter; and

attaching the attachment portion for the rail provided in the breaker to the pair of rail portions of the rail member attached to the horizontal portion of the plug-in adapter.

12. A method of producing a plug-in breaker configured with a breaker attachable to a rail in predetermined shape and dimensions and the plug-in adapter according to claim 7, the method comprising:

attaching the breaker to the horizontal portion of the plug-in adapter via the rail member; and

covering the gap between the vertical portion of the plug-in adapter and the breaker attached to the horizontal portion via the rail member with the terminal cover.

13. A rail for attaching one or more electrical/electronic devices to an object, the rail comprising a plurality of rail members integrally molded as a single component from a synthetic resin, wherein

the plurality of rail members are arranged in alignment with one direction,

two of the rail members adjacent to each other are coupled by a division portion with a thickness capable of being broken by applying an external force,

each of the rail members includes a base portion having a fixation portion to allow fixation to the object and a pair of rail portions in a shape and dimensions attachable to an attachment portion for the rail provided in the electrical/electronic devices, and

the base portion has an approximately quadrangular outline, the pair of rail portions are integrally molded with two facing sides of the base portion as a single component, and the rail portions of each rail member are arranged in alignment with a longitudinal direction of the rail.

14. The rail according to claim 13, wherein the fixation portion is a through hole allowing a screw to be inserted.

15. The rail according to claim 14, wherein the base portion has a first fixation portion to insert the screw from a front surface side of the rail member and a second fixation portion to insert the screw from a back surface side of the rail member.

16. The rail according to claim 14 or 15, wherein at least one of the fixation portion of the base portion is configured by partially combining a plurality of circular through holes with different diameters.

17. The rail according to any one of claims 13 through 16, wherein a third fixation portion as a through hole allowing a screw to be inserted is formed between two of the rail members adjacent to each other.

18. The rail according to claim 17, wherein the base portion has two side surfaces without the pair of integrally molded rail portions, the two side surfaces being integrally molded with a pair of approximately semicircular depressions as a single component, and the depressions of two of the rail members adjacent to each other form the third fixation portion.

19. The rail according to any one of claims 13 through 18, wherein at least one of the pair of rail portions has a back surface integrally molded with, as a single component, at least one convex portion to abut on the attachment portion for the rail.

20. A rail member for attaching one electrical/electronic device to an object, wherein the rail member is integrally molded from a synthetic resin, has a shape and dimensions corresponding to an attachment portion for a rail provided in the one electrical/electronic device, and includes: a base portion having a fixation portion to allow fixation to the object; and a pair of rail portions attachable to the attachment portion for the rail,

the base portion has an approximately quadrangular outline, the pair of rail portions are integrally molded with two facing sides of the base portion as a single component, and at least one of the pair of rail portions has a back surface integrally molded with, as a single component, at least one convex portion to abut on the attachment portion for the rail.