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(54) **A pole connector for in-series circuit breakers**

(57) The invention relates to a pole connector for in-series circuit breakers, and in particular miniature circuit breakers (MCB) installed alongside each other on a bus-bar. The connector is made in the form of an aluminum conducting element (1) comprising conducting terminals (3) and cooling ribs (4a) of a length of (Sa) located on the front of the connector. The connector according to the invention has additional cooling ribs (4b) of a length of (Sb) which make a fragment of the conducting element (1), which are located on the rear of the connector and which preferably are grouped in pairs between which a free space (6) is formed to let exhaust gases escape from individual circuit breakers, when the connectors have been mounted on the circuit breaker set. The external surface of the aluminum conducting element (1) with the ribs (4a) and (4b), with the exception of the conducting terminals (3), is covered with an electrically insulating coat (5) made of polyamide material of thermal conductivity exceeding 0.2 W/(m·K) and of dielectric strength of at least 15 kV/mm, or of polyurethane material of thermal conductivity exceeding 0.1 W/(m·K) and of dielectric strength of at least 10 kV/mm, which sticks tightly to the external surface of the conducting element (1).

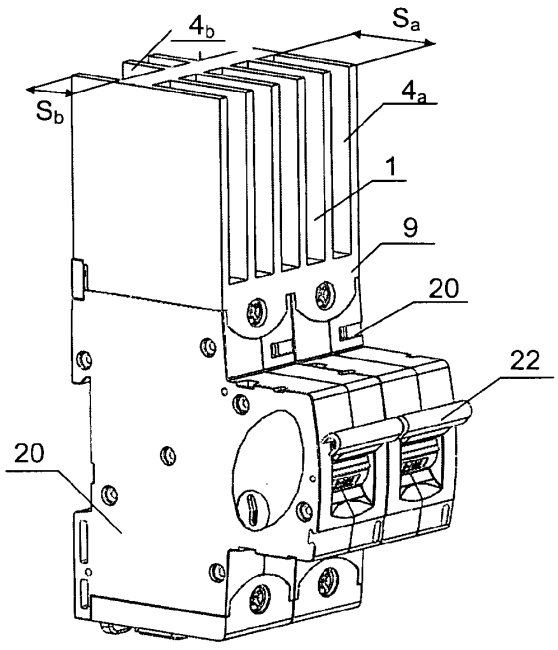

Fig. 8

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Description

[0001] The invention relates to a pole connector for in-series circuit breakers, and in particular to miniature circuit breaker (MCB) installed alongside each other on a busbar. In particular, the connector is suitable for use with circuit breakers of rated current in excess of 50A, used in photovoltaic equipment.

[0002] Circuit breakers used to protect photovoltaic equipment are exposed to high ambient temperatures during operation and they have to be resistant to high temperatures of up to 50 degrees centigrade. Circuit breakers which protect a photovoltaic panel are connected in twos in series and they are located before the photovoltaic panel and after it in the electric circuit. If circuit breakers of the upper range of rated currents are used, and in particular a circuit breaker of a rated current of 125 A, roughly 50% of heat generated by the flow of current through it is dispersed through conductors connected to each individual circuit breaker, i.e. the incoming and outgoing leads. By eliminating incoming conductors located in the upper part of the circuit breaker and replacing them with a short section of a conductor in the form of an electric connector, the possibility to carry away heat generated in the circuit breaker is eliminated which results in overheating the circuit breaker. In increased ambient temperature conditions that occur in the areas of application of photovoltaic equipment, the increased amount of heat generated in circuit breakers often leads to a considerable increase in temperature in the box in which they have been installed and consequently to fire.

[0003] The purpose of the invention is to design a new connector which, in addition to the ability to conduct current of intensity exceeding 50 A, and especially of 125 A, will be able to carry away heat generated by the flow of current through the connector and a part of heat generated by the flow of current through two MCBs connected in series.

[0004] At present, on the market there is available a connector offered by ABB under catalogue number 2CCS800900R0411, EAN No. 7612271211295 marked as S802-LINK50. The connector is a rectangular copper plate which is provided with two flat conducting terminals protruding above the plate, which are situated along the longer axis of the plate or parallel to that axis, the distance between the conducting terminals depending on the type of the circuit breakers that are to be electrically connected in pairs with each other, and corresponding to the distance between the circuit breaker terminals located in the cable holes of each MCB pair connected in series and situated on a common conducting bus. The connector terminals, after being placed in the circuit breaker cable hole, are connected with the circuit breaker terminals by means of press bolts or set screws. The copper plate protruding above the openings of the interconnected circuit breakers is covered by an insulating cover that covers the cable holes of the connected circuit breakers. The cover is made of plastic and its function is to electrically insulate the circuit breaker connectors. The S802-LINK50 connector allows the flow of maximum current of 50A which is limited by the ability of the connector to dissipate heat.

[0005] In its catalogue materials, Schneider Electric describes a connector used to connect two in-series circuit breakers, and in particular overcurrent circuit breakers. The connector consists of a rectangular conducting plate provided with a rectangular recess situated centrally in the plate plane on one of the longer sides of the plate, whose depth depends on the level of location of the breaker terminal in the cable hole of the circuit breaker. Elements of the conducting plate situated at both sides of the recess are parallel to one another and they make the connector terminals which are connected with the circuit breaker terminals, after the terminals have been placed in the cable holes of the circuit breakers that are to be connected with each other. Each terminal has an opening for a screw or bolt fixing the conducting plate to the circuit breaker terminals. A metal radiator in the form of a plate with protruding ribs parallel to one another and located on one of the flat surfaces of the plate, which ribs are grouped on the sides of the plate on the left and on the right, is attached to one of the flat surfaces of the plate. The central surface of the plate between the ribs on the left and right has suitable openings for placing in them bolts or screws that fix the radiator to the surface of the conducting plate of the connector. The connector terminals are placed in the cable holes of the circuit breaker in such way that the radiator ribs are in the upper and bottom part of the circuit breaker, on the same side as the lever used to change the operating status of the circuit breaker. A disadvantage of this connector is the lack of any electric insulation, which necessitates the use of an additional cover made of insulating material on the connector, which worsens the ability of the device to carry heat away.

[0006] The pole connector for a set of in-series circuit breakers mounted on a bus bar is made in the form of a conducting aluminum element which comprises conducting terminals and cooling ribs of a length of "Sa" which are located on the connector front. The connector according to the invention is **characterized in that** it has additional cooling ribs of a length of "Sb" constituting a fragment of the conducting element, which are located on the back of the connector. The external surface of the aluminum conducting element together with the cooling ribs with the exception of the conducting terminals is covered with an electrically insulating coat made of a polyamide material of thermal conductivity in excess of 0.2 W/(m·K) and of a dielectric strength of at least 15 kV/mm or of a polyurethane material of a thermal conductivity in excess of 0.1 W/(m·K) and of a dielectric strength of at least 10 kV/mm, which sticks tightly to the external surface of the conducting element.

[0007] Preferably cooling ribs of a length of "Sb" are grouped in pairs between which a free space is formed to allow escape of exhaust gases from individual circuit

breakers, after installation of the connectors on the circuit breaker set.

[0008] Preferably, the cooling ribs have the form of vertical plates situated parallel to one another, and their height "H" is bigger than the length "Sa" and the length "Sb", and the length of the ribs on the front of the connector is bigger than the length of the ribs on the back of the connector.

[0009] Preferably, a framing comprising a transverse shield constituting an integral part of the conducting element is connected to the ends of the extreme ribs situated on the front of the connector, on the side where the conducting terminals are located. The shield is connected with the bottom wall that connects the ribs on the bottom part of the connector. The bottom part of the shield has the shape of semicircles connected with one another.

[0010] Preferably there are ports situated in the semicircles of the shield.

[0011] Alternatively, the cooling ribs of the bigger width Sa are made of irregular elements which in outline, on the front side of the connector, have a shape similar to the cross- section of the walls of a goblet whose bottom part is surrounded, on the outside of the goblet, by fragments of the parallel bottom walls of the goblet, a longitudinal partition is located in the longitudinal axis of the goblet, and in the upper part of the goblet between the longitudinal partition and the goblet walls there are located side partitions. The bottom of the goblet is situated on the same side as the connector terminals, or on the other side.

[0012] A set of circuit breakers for mounting on a busbar comprises at least one pair of circuit breakers electrically connected with each other by means of a connector for in-series circuit breakers, in which individual circuit breakers have cable holes in which terminals to be connected with the connector are placed. Each circuit breaker has a front side with an "ON" and "OFF" status switch and a back side situated parallel to the front side. The circuit breaker set according to the invention is characterized by the fact that the connector is made according to any of the claims 1 through 5, and the back side of the connector comprises cooling ribs situated at the back of the circuit breakers and it has free spaces between these ribs, whose function is to let out gases from the circuit breakers if a short circuit occurs in the circuit breakers.

[0013] The connector according to the invention is characterized by simple design and small dimensions, which permits its use in circuit breaker sets used in standard connection boxes. The connector has remarkably high ability to dissipate heat by natural convection and it is excellently suitable for applications in photovoltaic equipment. At the same time, the connector is distinguished by its dielectric strength, which makes it safe and eliminates electric shock hazard even if it is touched. An additional advantage is its resistance to the harmful effect of gases blown out from the arc chamber, produced by the arc generated while disconnecting fault current in the MCB. Another advantage of the connector is the simple process of its production.

[0014] The invention is presented as an embodiment in the drawing where fig. 1 shows the connector in top view, fig. 2 - a section through the connector from fig. 1 along the line "A-A", fig. 3 - the connector in the first variety of the invention embodiment in axonometric projection, fig. 4 - the connector in the second variety of the invention embodiment in axonometric projection, fig. 5 - the connector in the third variety of the invention embodiment and in the first version of its embodiment in axonometric projection, fig. 6 - the connector in the third variety of the invention embodiment and in the second version of its embodiment in axonometric projection, fig. 7 - a set of circuit breakers with the connector made according to the first variety of the invention embodiment in axonometric projection, fig. 8 - a set of circuit breakers with the connector made according to the second variety of the invention embodiment in axonometric projection, fig. 9 - a set of circuit breakers with the connector made according to the third variety of the invention embodiment and in the first version of its embodiment in axonometric projection, and fig. 10 - a set of circuit breakers with the connector made according to the third variety of the invention embodiment and in the second version of its embodiment in axonometric projection.

[0015] The connector according to the invention is an aluminum conducting element 1 consisting of a base plate 2, conducting terminals 3 situated perpendicularly to the plate 2 on the same side of the plate, and cooling ribs 4a and 4b, extending on both sides of the plate 2, perpendicularly to the flat surface of the plate. The shape and the dimensions of the terminals 3 fit the shape and dimensions of the cable holes made in the circuit breakers that are being connected with each other. All elements of the connector constitute one integrated whole, although in fig. 2 the plate 2 is separated from the terminals 3 by a dashed line, which allows to better explain the invention. The whole surface of the conducting aluminum element 1, with the exception of the terminals 3, is covered by an electrically insulating coat 5 made of polyamide material of thermal conductivity in excess of 0.2 W/(m·K) and of dielectric strength of at least 15 kV/mm, or of polyurethane material of thermal conductivity in excess of 0.1 W/(m·K) and of dielectric strength of at least 10 kV/mm, which sticks tightly to the external surface of the element 1, with the exception of its terminals 3.

[0016] The number of cooling ribs is different on the two sides of the plate 2. More ribs are on the front side of the connector, which side, after the connector has been installed on the circuit breaker, is situated on the front of the circuit breaker. The length of these ribs measured in the direction perpendicular to the flat surface of the plate 2 of the element 1 is marked as Sa. Less ribs are on the rear side of the connector, which side, after the connector has been installed on the circuit breaker, is situated at the back of the circuit breaker. The length of these ribs measured in the direction perpendicular to the flat surface

of the plate 2 of the element 1 is marked as Sb. The length Sa is bigger than the length Sb. The ribs 4a and 4b extend along the height H of the connector, the height H being much bigger than the length of the ribs Sa and Sb. The ribs of the length Sb are grouped in pairs between which there are free spaces 6. The free spaces 6, situated between the individual ribs 4b, after the connector has been installed on the circuit breaker, facilitate flow of exhaust gases from the circuit breaker during its operation.

[0017] The aluminum element 1 is produced in a high-pressure die casting process in a mold of a complex shape. Next, depending on the type of material used for the coat 5, the aluminum element is preheated to a temperature of 50 - 90 °C if polyamide coat is used, or to a temperature of 50 - 60 °C if polyurethane coat is used. The preheated aluminum element 1 is coated with the coat 5 using the overmolding process in a die whose temperature is equal to the temperature of the preheated aluminum element 1. After the completion of the process of coating by casting liquid polyamide or polyurethane material into the mold, the coat 5 is hardened either by reducing the temperature below the freezing point of the polyamide material for the coat made of the polyamide material, or through known chemical reactions if polyurethane material is used.

[0018] **In the first variety** of its embodiment, the invention comprises vertical ribs 4a and 4b which are situated parallel to each other on each flat side of the base plate 2.

[0019] **In the second variety** of its embodiment, the invention comprises vertical ribs 4a and 4b which are situated parallel to each other on each flat side of the base plate 2, a framing 4c surrounding the bottom contour of the connector at the front and sides of the connector being attached to the bottom ends of the ribs, which framing constitutes a whole with the aluminum element 1. In the drawing, the framing 4c is marked by a conventional dashed line. The framing 4c is integrated with the aluminum element 1 and it comprises an external transverse shield 7 parallel to the surface of the plate 2, joining the individual ribs 4a on the bottom part of the ribs, which is fixed also to the bottom wall 8 closing the space between the ribs 4a on their lower side. The shield 7 has the shape of flat semicircles 9 fixed to the framing 4c on the front of the connector. In the semicircles 9 there are ports 10 through which the bolts of the cable terminals of the connector are tightened, which is not shown in the drawing. The shape of the shield 7 is adjusted to the circuit breaker design, so that after the installation of the connector on the circuit breakers, the shield covers the space under the connector including the upper parts of two neighboring circuit breakers.

[0020] **In the third variety** of its embodiment, the invention is presented In two versions. In the first version the connector comprises ribbings 4a and 4b, which are made as follows. The ribbing 7b is made in the form of vertical ribs as in the first and second variety of the invention embodiment, whereas the ribs 4a on the front of the connector have different shapes, and their general view has a shape similar to the cross-section of the walls of a goblet 11. The bottom part of the goblet walls is surrounded, on the outside of the goblet, by fragments of the parallel bottom walls of the goblet 12. A longitudinal partition 13 is located in the longitudinal axis of the goblet, and in the upper part of the goblet, between the longitudinal partition 13 and the walls of the goblet 11, side partitions 14 are located. In this variety, the bottom of the goblet is situated on the same side of the connector on which the terminals 3 of the connector are located.

[0021] **In the second version of the third variety of the invention embodiment,** the connector has the same elements as in the first version of this variety of the invention embodiment, but the bottom of the goblet is situated on the side of the connector opposite to that on which the terminals 3 of the connector are located.

[0022] The terminals 3 of the connector according to the invention are clamped in the cable holes of the circuit breakers 20, so that one connector terminal is clamped in the cable hole of one circuit breaker, and the second connector terminal is clamped in the second cable hole of the second circuit breaker, by which an electric in-series coupling between the circuit breakers 20 is obtained. Depending on the type of the connector used and the circuit breakers which may comprise or not insulating covers 21 located on their upper parts, various practical sets of circuit breakers are obtained which are ready for installation on the busbar in the connection box of electric equipment protected by such sets. The connectors according to the invention are placed in a single set in such way that the front wall of the connector, comprising the cooling ribs 4a of the bigger length Sa, is situated on the front side of both circuit breakers, comprising the "ON" / "OFF" switch marked as 22. The rear wall of the connector, comprising the cooling ribs of the lesser length Sb, is situated on the rear sides of the two circuit breakers.

Examples of circuit breaker sets for installation on a bus are shown in fig. 7-10.

[0023] The set in fig. 7 comprises two circuit breakers 20 coupled with the connector according to the invention. In the presented set, the circuit breakers 20 are provided with insulating covers 21 located on the front walls of the circuit breakers, comprising operating status switches 22. In this case, between the lower part of the connector and the upper walls of the circuit breakers there is an air gap situated around the lower part of the connector. In the insulating covers there are holes through which a set screw is inserted which fixes the terminals 3 to the terminals of the circuit breakers, which are not shown in the drawing.

[0024] The set in fig. 8 comprises two circuit breakers 20 coupled with each other by means of the connector according to the invention. In this combination, the circuit breakers 20 lack the insulating covers 21, because their

function is performed by the shield 7 and the framing 4c of the connector made according to the third variety of the invention embodiment.

[0025] The sets shown in fig. 9 and fig. 10 comprise two circuit breakers 20 coupled with each other by means of the connector which is made according to the third and fourth variety of the invention embodiment, and the circuit breakers 20 have the insulating covers 21.

Claims

1. A pole connector for a set of in-series circuit breakers mounted on a bus bar, made in the form of an aluminum conducting element (1), comprising conducting terminals (3) and cooling ribs (4a) of a length of (Sa) placed on the front of the connector, **characterized in that** it has additional cooling ribs (4b) of a length of (Sb) which make a fragment of the conducting element (1) and which are located on the back of the connector, and the external surface of the aluminum conducting element (1) with the ribs (4a) and (4b) with the exception of the conducting terminals (3), is covered by an electrically insulating coat (5) made of polyamide material of thermal conductivity in excess of 0.2 W/(m·K) and of dielectric strength of at least 15 kV/mm, or of polyurethane material of thermal conductivity in excess of 0.1 W/(m·K) and of dielectric strength of at least 10 kV/mm, which sticks tightly to the external surface of the conducting element (1).

2. A connector according to claim 1, **characterized in that** the cooling ribs (4b) of a length of (Sb) are grouped in pairs between which a free space (6) is formed to permit escape of exhaust gases from individual circuit breakers, after the connectors have been installed on the circuit breaker set.

3. A connector according to claim 1, **characterized in that** the ribs (4a) and (4b) have the form of vertical ribs situated parallel to one another, and their height (H) is bigger than the length (Sa) of the ribs (4a) and bigger than the length (Sb) of the ribs (4b), and the length of the ribs (Sa) on the front of the connector is bigger than the length (Sb) of the ribs on the back of the connector.

4. A connector according to claim 3, **characterized in that** to the ends of the extreme ribs (4a), on the side where the terminals (3) are situated, there is connected a framing (4c) comprising a crosswise shield (7) constituting an integral part of the conducting element (1), connected with the bottom wall (8) that connects the ribs (4a) on the bottom of the connector, and the bottom part of the shield (7) has the shape of interconnected semicircles (9).

5. A connector according to claim 4, **characterized in that** there are ports (10) situated in the semicircles (9).

6. A connector according to claim 1, **characterized in that** the cooling ribs (4a) of the bigger length (Sa) are made of irregular elements which in outline, on the front side of the connector, have a shape similar to a cross-section of the walls of a goblet (11) whose bottom part is surrounded, on the outside of the goblet, by fragments of the parallel bottom walls of the goblet (12), a longitudinal partition (13) is located in the longitudinal axis of the goblet, and in the upper part of the goblet between the partition (13) and the goblet walls (11) there are located side partitions (14), the bottom of the goblet (11) being situated on the same side as the terminals (3) of the conducting element (1), or on the other side.

7. A set of connectors for mounting on a busbar, comprising at least one pair of circuit breakers (20) electrically connected with each other by means of a connector for in-series circuit breakers, in which individual circuit breakers (20) have cable holes in which terminals for connecting with the connector are located, and each circuit breaker has a front side with an "ON" / "OFF" status switch (22) and a rear side situated parallel to the front side, **characterized in that** the connector is made according to any of the claims 1-6, and the rear side of the connector comprising the cooling ribs (4b) is situated on the rear side of the circuit breakers and it has free spaces (6) between the ribs (4b) intended for letting out gases from the circuit breakers if a short circuit occurs in the circuit breakers.

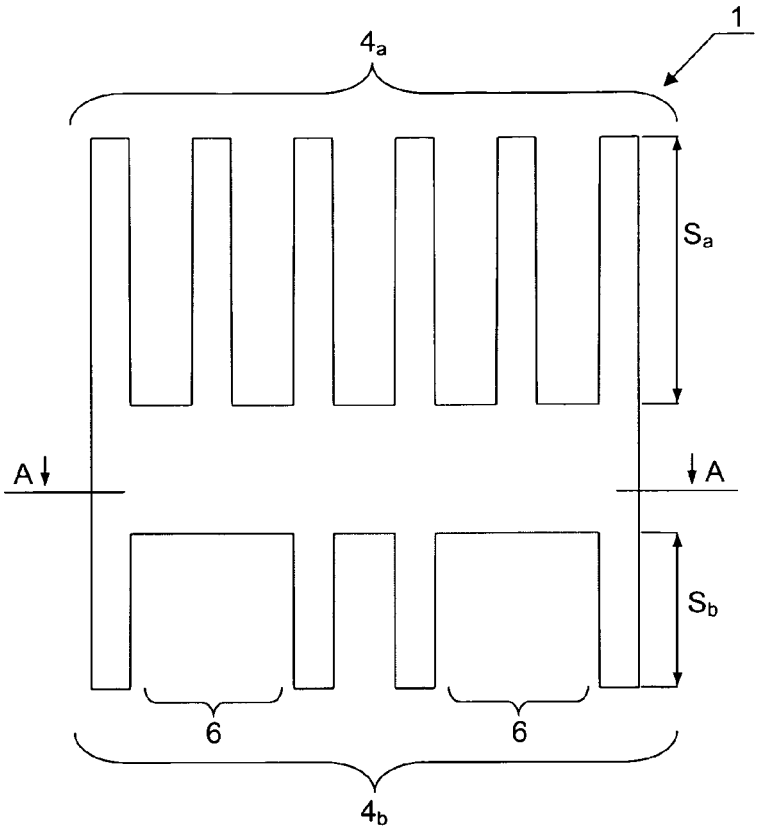

Fig. 1

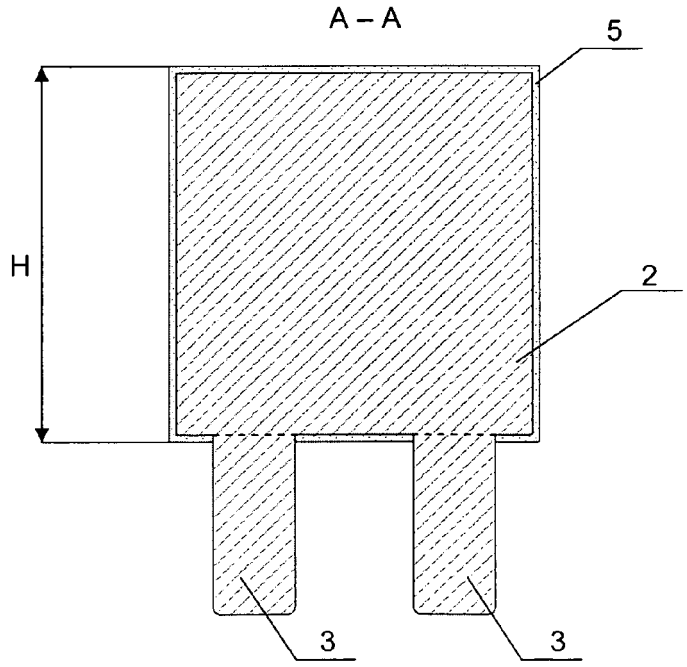

Fig. 2

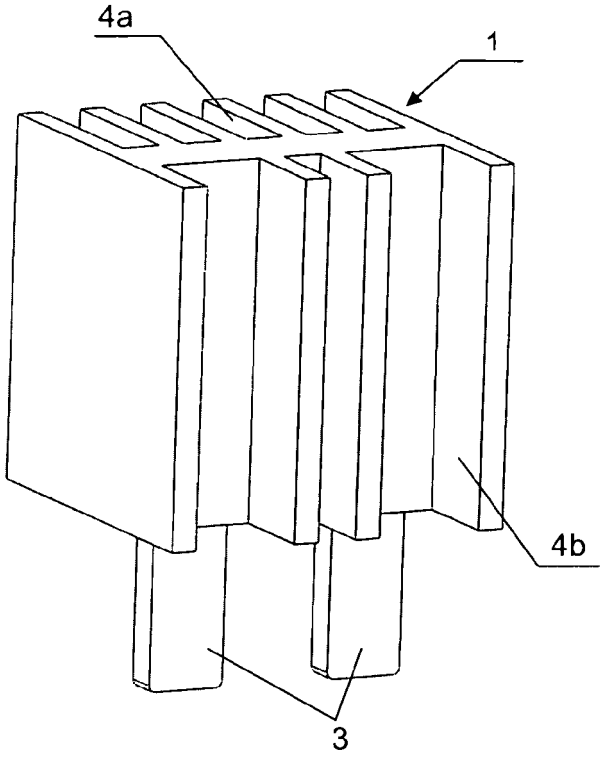

Fig. 3

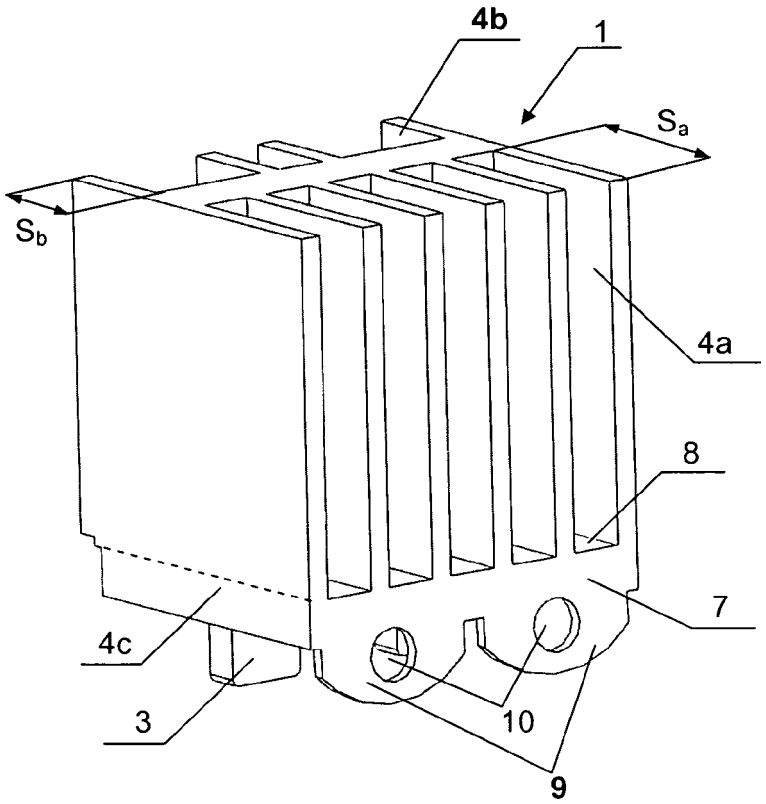

Fig. 4

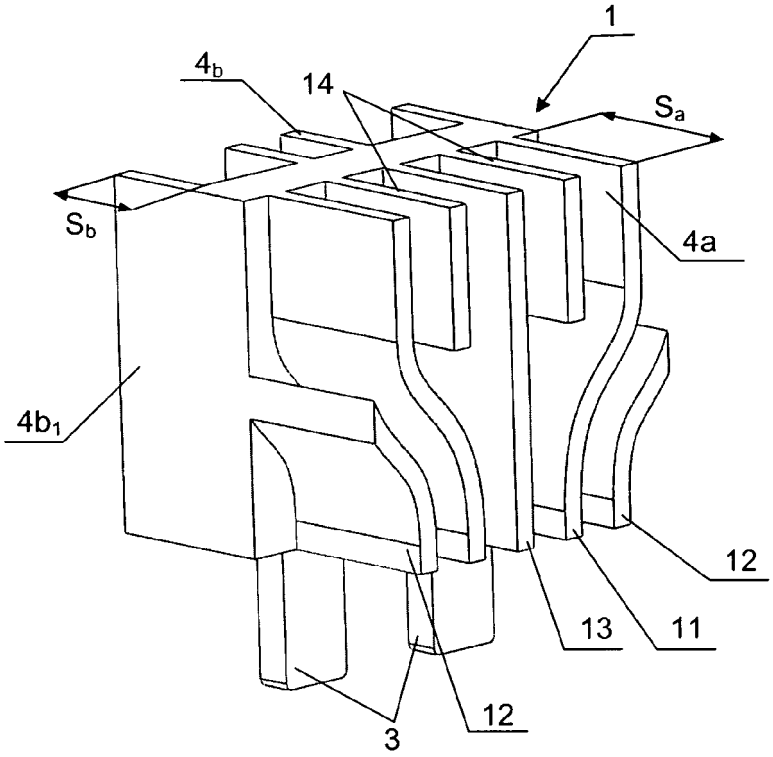

Fig. 5

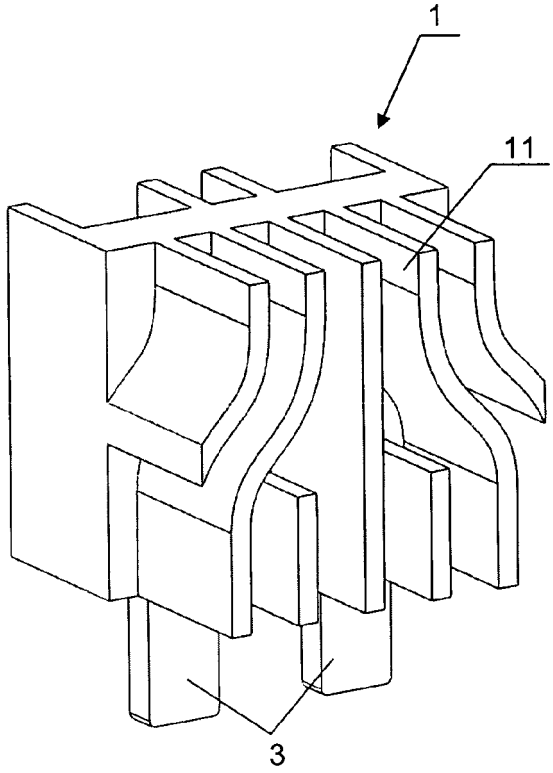

Fig. 6

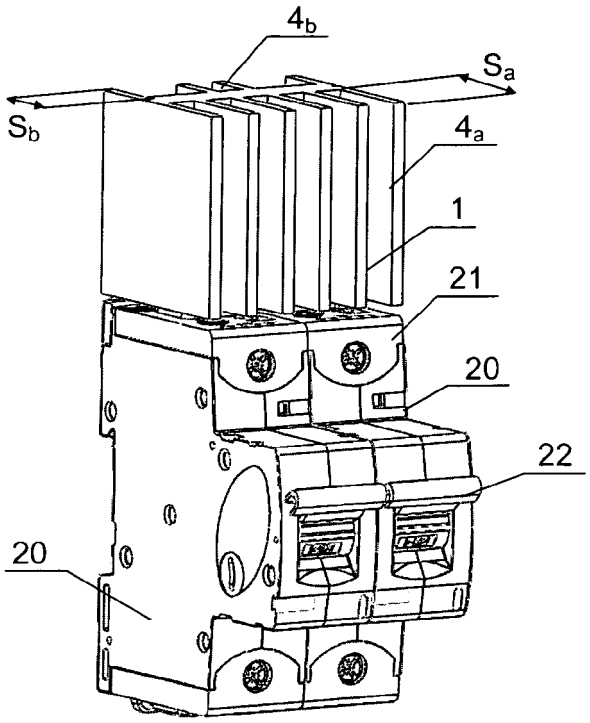

Fig. 7

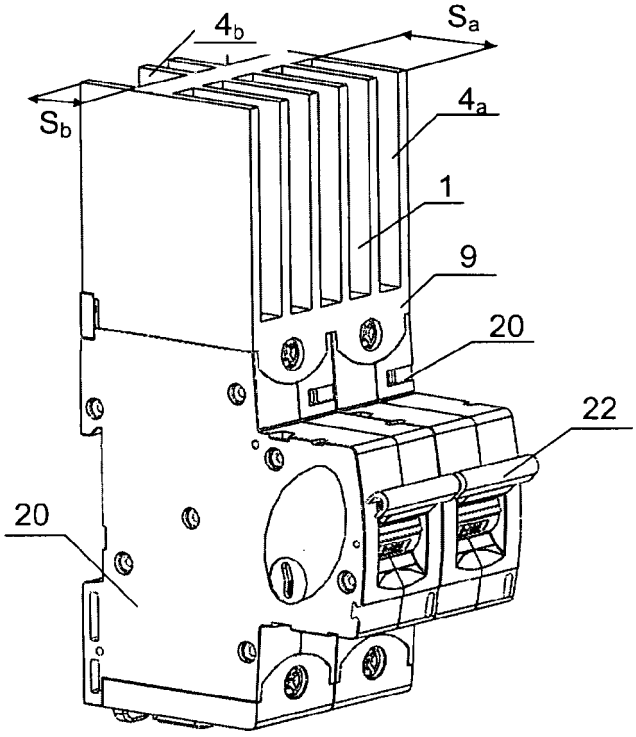

Fig. 8

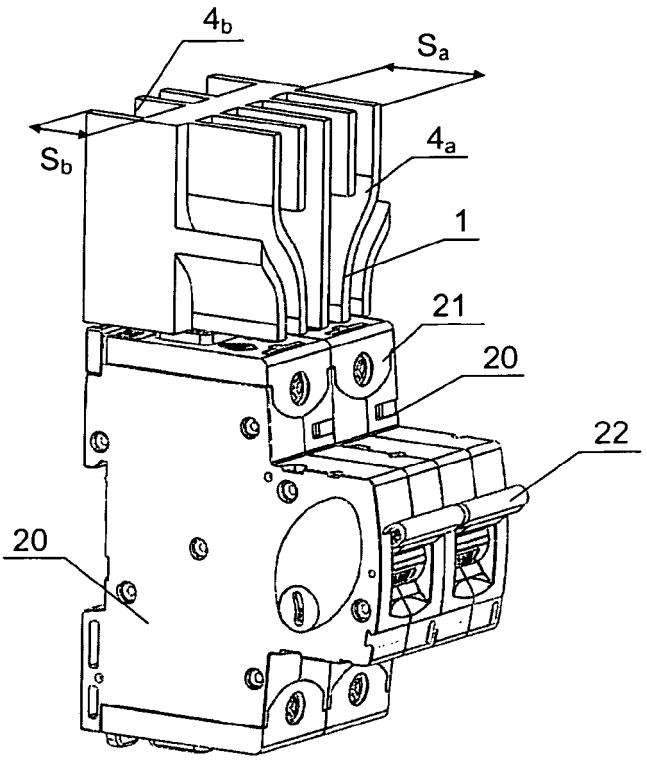

Fig. 9

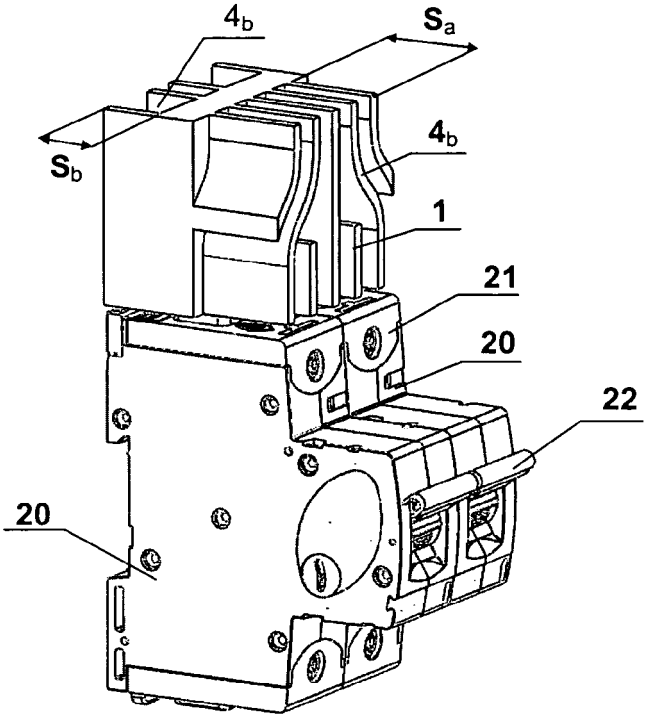

Fig. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 12 46 0013

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	CN 201 130 238 Y (TIANJIN BAILI ELECTRIC CO LTD [CN]) 8 October 2008 (2008-10-08) * the whole document *	1	TECHNICAL FIELDS SEARCHED (IPC) H01R H01L H05K H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	2 August 2012	Salojärvi, Kristiina

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 46 0013

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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