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(54) DC CURRENT BREAKER DEVICE

(57) A direct current circuit breaker is provided at a coupling point where three or more direct current power transmission lines (11 to 13) are electrically coupled in a direct current power transmission line network. The direct current circuit breaker includes three or more series circuits (2), each of the series circuit being connected to ends of two different direct current power transmission lines, and including a serial connection of two or more current disconnectors (21), and three or more wire connection circuits (3), one end of each of the wire connection circuits being connected to a middle point of the series circuit, and another end being connected to one point where other ends of the wire connection circuits are connected to, each of the wire connection circuits including a commutation circuit (31) in which a current is commutated.

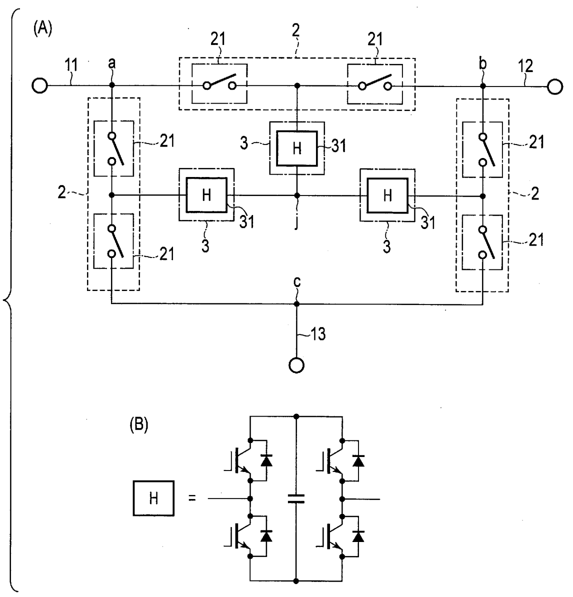

FIG. 1

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Description

Technical Field

[0001] Embodiments of the present invention relate to a direct current (DC) circuit breaker suitable for a DC power transmission line network.

Background Art

[0002] In recent years, the spread of renewable energy, such as wind power generation, photovoltaic power generation, and solar heat power generation, has been encouraged. Off-shore wind power generation, photovoltaic and solar heat power generation in desert areas have been considered to supply a larger amount of power from renewable energy.

[0003] With off-shore wind power generation, it is necessary to transmit large amounts of generated power through submarine cables to cities where electricity is largely consumed; with photovoltaic and solar heat power generation, it is necessary to transmit power effectively over a long distance, from the desert areas in Africa or up-country in China to Europe and coastal metropolises.

[0004] The demand for such long-distance power transmission leads to consideration of construction of a DC power transmission line network because DC power transmission is more efficient than conventional three-phase AC power transmission, and providing such a network can realize cost-savings.

[0005] DC power transmission requires power converting devices, such as converters for converting generated AC power to DC for DC power transmission and inverters for converting transmitted DC into AC for intra-city use. To avoid a higher harmonic wave due to switching in converters and inverters from flowing in an AC system, development and commercialization of a modular multilevel converter circuit capable of outputting a voltage waveform similar to a sine wave has been underway.

[0006] Compared to a conventional AC power transmission system, a DC power transmission system can be installed with a low cost if the system is applied to long-distance and greater-scale power transmission, and it is possible to construct such a system with high efficiency and less loss in power transmission; on the other hand, it is difficult to interrupt a current in a site where a system fault occurs due to lightening strike, etc.

[0007] In an AC system, a current can be interrupted at high speed by a mechanical-contact breaker at the point where an AC current crosses a zero current for every half cycle of the AC frequency of 50 Hz or 60 Hz, whereas in a DC system, a current cannot be easily interrupted by a mechanical contact breaker because a DC current does not cross a zero current. There is a way of interrupting a current using a semiconductor element; however, since a large current always flows in transmission lines, a large amount of conduction loss is steadily observed in such a semiconductor element.

[0008] To establish a power transmission line network, it is requested to continue an operation only with fault-free power transmission line networks by cutting off a fault-occurring point from the power transmission line network shortly after a fault occurs; thus, a DC circuit breaker like the one shown in FIG. 6 has been proposed.

[0009] The circuit diagram (A) in FIG. 6 shows a circuit configuration of the DC circuit breaker 4, and the circuit diagram (B) in FIG. 6 specifically shows a circuit element configuration of the commutation circuit 31 (H) shown in the diagram (A) of FIG. 6.

[0010] In FIG. 6, only positive electrode lines of the DC power transmission lines are shown, and negative electrode lines are omitted. Hereinafter, only the positive electrode lines are shown and the negative electrode lines are omitted in the drawings.

[0011] The DC circuit breaker 4 has a circuit configuration in which two series circuits 2 each consisting of two mechanical contact type current disconnectors 21 are connected in parallel and the middle points thereof are connected by a wire connection circuit 3 consisting of a commutation circuit 31.

[0012] The commutation circuit 31 has a single-phase full bridge configuration, having a capacitor as a DC voltage source. The DC circuit breakers 4 are inserted in series at a required point in the power transmission lines 11 of the DC power transmission line network.

[0013] According to this DC current circuit breaker 4, during a steady operation, all the mechanical contact type current disconnectors 21 are turned on, contrary to the state shown in (A) of FIG. 6. In this steady operation, a regular DC flows through the mechanical contact type current disconnectors 21.

[0014] When a system fault occurs, two mechanical contact type current disconnectors 21 that are arranged on a diagonal line are turned off, and the other two mechanical contact type current disconnectors 21 which stay in an ON state are used so that a current flows in the mechanical contact type current disconnector 21, the commutation circuit 31, and mechanical contact type current disconnector 21. Subsequently, a current flowing in the commutation circuit 31 is controlled to decrease to zero, and at the instant when a current flowing in the mechanical contact type current disconnectors 21 becomes zero, the remaining two mechanical contact type current disconnectors 21 are turned off. A fault current can be thereby interrupted.

[0015] However, in the DC circuit breaker 4 shown in FIG. 6, it is necessary to place one above-described DC current circuit breaker 4 in each of the DC power transmission lines 11, 12, and 13 as shown in FIG. 7, so that only a system where a fault occurs can be cut off at a coupling point k where two or more, for example, three DC power transmission lines 11, 12, and 13 are coupled.

[0016] As a result, the number of components required for such a system is increased overall, and the increase of the components leads to an increase of cost and size.

[0017] For this reason, it is desired to reduce the number of components and to provide a compact DC circuit breaker with a low cost, while being able to interrupt a fault current at high speed at a coupling point of multiple DC power transmission lines.

Disclosure of Invention

[0018] According to one embodiment, there is provided a direct current circuit breaker that is provided at a coupling point where three or more direct current power transmission lines are electrically coupled in a direct current power transmission line network, the breaker comprising: three or more series circuits, each of the series circuit being connected to ends of two different direct current power transmission lines, and including a serial connection of two or more current disconnectors; and three or more wire connection circuits, one end of each of the wire connection circuits being connected to a middle point of the series circuit, and another end being connected to one point where other ends of the wire connection circuits are connected to, each of the wire connection circuits including a commutation circuit in which a current is commutated.

[0019] According to another embodiment, there is provided a direct current circuit breaker that is provided at a coupling point where three or more direct current power transmission lines are electrically coupled in a direct current power transmission line network, the breaker comprising: three or more series circuits, each of the series circuits being connected to ends of two different direct current power transmission lines, and including a serial connection of two or more elements which includes a commutation means; and three or more wire connection circuits, each of the wire connection circuits including a current disconnector, one end of the current disconnector being connected to a middle point of the series circuit, and another end being connected to one point where other ends of the current disconnectors are connected to.

Brief Description of Drawings

[0020]

FIG. 1 is a diagram showing a configuration of a DC circuit breaker according to a first embodiment.

FIG. 2 is a step-by-step diagram showing procedures for controlling on/off of mechanical-contact current disconnectors in the event of a fault according to the embodiment.

FIG. 3 is a diagram showing a configuration of a DC circuit breaker according to a second embodiment.

FIG. 4 is a diagram showing a configuration of a DC circuit breaker according to a third embodiment.

FIG. 5 is a diagram showing a configuration of a DC circuit breaker according to a fourth embodiment.

FIG. 6 is a diagram showing a circuit configuration of a common DC circuit breaker.

FIG. 7 is a diagram showing a configuration example in which DC circuit breakers of FIG. 6 are arranged around a coupling point of three DC transmission lines.

[0021] Mode for Carrying Out the Invention Embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

(First Embodiment)

[0022] FIG. 1 is a diagram of a configuration of a DC circuit breaker according to the first embodiment of the present invention.

[0023] As shown in (A) of FIG. 1, DC circuit breakers are provided at a coupling point where three DC power transmission lines 11, 12, and 13 are electrically coupled. The DC power transmission lines 11, 12, and 13 are connected to each other by series circuits 2 each consisting of two mechanical contact type current disconnectors 21. The series circuits 2 at the coupling points of the three DC power transmission lines 11, 12, and 13 form a delta connection for points a, b, and c on the line paths.

[0024] One end of the wire connection circuit 3 including a commutation circuit 31 (H) is connected to the middle point of two mechanical contact type current disconnectors 21 in each series circuit 2, and the other end is connected to a contact point j where all the other ends of the wire connection circuits 3 are connected. These wire connection circuits 3 serve as a star wire connection.

[0025] As shown in (B) of FIG. 1, the commutation circuit 31 has a single-phase full bridge configuration, having a capacitor as a voltage source.

[0026] A not-illustrated control circuit controls an ON/OFF operation of all the mechanical contact type current disconnectors 21 of the series circuits 2 in accordance with a time when a steady operation is carried out or when a fault occurs in any of the power transmission lines.

[0027] The control circuit also controls an output voltage of the commutation circuit 31 in the wire connection circuit 3.

[0028] Next, the operation at the time of interrupting a current in the DC circuit breaker according to the present embodiment will be described. During a steady operation, the control circuit turns on the mechanical contact type current disconnectors 21 in all the series circuits 2, so that a current is transmitted through the mechanical contact type current disconnectors 21.

[0029] As shown in (A) of FIG. 2, when a fault occurs in one DC power transmission line, for example, the DC power transmission line 13, a fault current (if) flows toward the DC power transmission line 13. When the fault is detected, the control circuit turns off the mechanical-contact current disconnectors 2a, which constitutes a pair with respect to the contact point j, as shown in (B) in FIG. 2, so that a fault current (if) flows through the mechanical-contact current disconnectors 21, the commutation circuit 31, and the mechanical-contact current disconnector

2b.

[0030] Herein, the control circuit controls an output voltage and an amount of current, so that the fault current (if) in the commutation circuit 31 decreases to zero. Then, at the time when a current decreases to zero, as shown in (C) of FIG. 2, the mechanical-contact current disconnector 2b where the fault current (if) is flowing is turned off, so that the DC power transmission line 13 where the fault has occurred is cut off.

[0031] In a case where a fault occurs in the DC power transmission line 11, 12, or 13 of other systems other than the DC power transmission line 13, it is possible to cut off the DC power transmission line where the fault has occurred by performing similar processing.

[0032] According to the above-described embodiment, compared to a case where conventional DC current circuit breakers shown in FIG. 6 are respectively connected to the DC power transmission lines 11, 12, and 13, it is possible to reduce the size of the series circuit 2 by half, and to reduce the overall number of components, thereby realizing a DC current breaker with a low cost and a compact size.

[0033] The matters common in the present embodiment and the second embodiment will be described below.

[0034] A similar operation can be carried out with semiconductor breakers, instead of the mechanical contact type current disconnectors 21.

[0035] As shown in FIG. 1, one mechanical contact type current disconnector 21 is provided in each series circuit 2 across a middle point from another mechanical contact type current disconnector 21; however, the series circuits 2 may be configured to be connected to two or more mechanical contact type current disconnectors 21 in series across the middle point from two or more other mechanical contact type current disconnectors 21.

[0036] Two or more commutation circuits 31 may be connected in series to constitute a wire connection circuit 3. If a direction of controlling a current in the commutation circuit 31 is limited, the commutation circuit 31 may be configured as a half-bridge circuit.

[0037] For example, a reactor may be provided in series on the line paths connecting the points a, b, and c. This reactor can suppress a peak of an alternating current flowing in the event of a fault, and makes it easy to interrupt a current in the mechanical contact type current disconnectors 21a by decreasing a frequency of the alternating current and lowering a gradient of the alternating current.

(Second Embodiment)

[0038] FIG. 3 is a diagram showing a configuration of a DC circuit breaker according to the second embodiment. Since a basic concept is the same as the configuration illustrated in FIG. 1, the constituent elements the same as or corresponding to those of the DC circuit breaker illustrated in FIG. 1 will be referred to by the same reference symbols as those used in FIG. 1.

[0039] The present embodiment discloses a configuration example of the DC circuit breakers at the coupling point of four DC power transmission lines 11-14. At the coupling point, two neighboring lines of the DC power transmission lines 11-14 are connected by series circuits 2 each consisting of two mechanical contact type current disconnectors 21.

[0040] One end of the wire connection circuit 3 including a commutation circuit 31 (H) is connected to the middle point of two mechanical contact type current disconnectors 21 in each series circuit 2, and the other end is connected to a contact point j where all the other ends of the wire connection circuits 3 are connected.

[0041] As shown in (B) of FIG. 1, the commutation circuit 31 has a single-phase full bridge configuration, having a capacitor as a voltage source.

[0042] A not-illustrated control circuit controls an ON/OFF operation of all the mechanical contact type current disconnectors 21 of the series circuits 2 in accordance with a time when a steady operation is carried out or when a fault occurs in any of the power transmission lines.

[0043] The control circuit also controls an output voltage of the commutation circuit 31 in the wire connection circuit 3.

[0044] The current interruption operation in the present DC circuit breaker is similar to that in the first embodiment, and even when a fault occurs in any of the DC power transmission lines 11-14, the DC power transmission line where the fault has occurred can be cut off in a short time.

[0045] According to the present embodiment, compared to a case where conventional DC current circuit breakers shown in FIG. 6 are respectively connected to the DC power transmission lines 11-14, it is possible to reduce the overall number of components in the series circuits 2, thereby realizing a DC current breaker with a low cost and a compact size.

[0046] To connect a conventional DC circuit breaker shown in FIG. 6, if there are n lines of DC power transmission lines, 2n series circuits 2 consisting of mechanical contact type current disconnectors 21 are required. In contrast, only a half of the number, that is, *n* series circuits 2 are required in the present embodiment.

[0047] Furthermore, even in a case of contact points of five or more DC power transmission lines, a configuration similar to the present embodiment can reduce the number of components by half.

[0048] In FIG. 3, the DC power transmission line 11 is connected to the DC power transmission lines 13 and 14 by the series circuits 2, for example; however, since all the DC power transmission lines 11-14 are equivalent, the DC power transmission lines 12 and 13, or the DC power transmission lines 12 and 14 may be connected to the DC power transmission line 11 by the series circuits 2. The same applies to the other DC power transmission lines.

(Third Embodiment)

[0049] FIG. 4 is a diagram showing a configuration of a DC circuit breaker according to the third embodiment. Since a basic concept is the same as the configuration illustrated in FIG. 1, the constituent elements the same as or corresponding to those of the DC circuit breaker illustrated in FIG. 1 will be referred to by the same reference symbols as those used in FIG. 1.

[0050] As shown in (A) of FIG. 4, the DC circuit breakers according to the present embodiment connect the DC power transmission lines 11, 12, and 13 by the series circuits 2 each consisting of the reactor 22 and the semiconductor circuit breaker 23 at the coupling point where three DC power transmission lines 11, 12, and 13 are electrically connected.

[0051] As shown in (B) of FIG. 4, each semiconductor circuit breaker 23 is connected in series in such a manner that two semiconductor switching elements 231 are directed in opposite directions, and an arrestor 232 is connected the semiconductor switching elements 231 in parallel.

[0052] The series circuits 2 at the coupling point of the three DC power transmission lines 11, 12, and 13 form a delta connection for points a, b, and c on the line paths. One end of the wire connection circuit 3 including a commutation circuit 32 is connected to the middle point of the reactor 22 and the semiconductor circuit breaker 23 in each series circuit 2, and the other end is connected to a contact point j where all the other ends of the wire connection circuits 3 are connected. These wire connection circuits 3 serve as a star wire connection.

[0053] A not-illustrated control circuit controls an ON/OFF operation of all the semiconductor circuit breakers 23 of the series circuits 2 in accordance with a time when a steady operation is carried out or when a fault occurs in any of the power transmission lines.

[0054] The control circuit also controls an ON/OFF operation of the mechanical-contact current disconnector 32 in the wire connection circuit 3.

[0055] Next, the operation at the time of interrupting a current in the DC circuit breaker according to the present embodiment will be described.

[0056] During a steady operation, the control circuit turns on all the mechanical contact type current disconnectors 32 but turns off all the semiconductor circuit breakers 23, so that a current is transmitted through the mechanical-contact current disconnectors 32 and the reactors 22.

[0057] When a fault occurs in a DC power transmission line, a fault current (if) flows toward the DC power transmission line where the fault occurs. When the control circuit detects the fault, the control circuit turns on the semiconductor circuit breaker 23 connected to a DC power transmission line where the fault occurs. Then, the fault current (if) flowing in the reactor 22 and the mechanical-contact current disconnector 32 that are connected to the DC power transmission line where the fault has occurred flows in the semiconductor circuit breaker 23 that is turned on. At this time, at this instance when a zero current flows in the mechanical-contact current disconnector 32, the control circuit turns off the mechanical-contact current disconnector 32. Next, the semiconductor circuit breaker 23 to which the flow of the fault current has been shifted is turned off. The DC power transmission line where the fault has occurred can be thereby cut off.

[0058] In a case where a fault occurs in other systems, by performing similar processing, it is possible to cut off the DC power transmission line where the fault occurs even when the fault occurs in any of the DC power transmission lines.

[0059] According to the above-described embodiment, compared to a case where conventional DC current circuit breakers shown in FIG. 6 are respectively connected to the DC power transmission lines 11, 12, and 13, it is possible to reduce the size of the series circuit 2 by half, and to reduce the overall number of components, thereby realizing a DC current breaker with a low cost and a compact size.

[0060] In the semiconductor circuit breaker 23, four or more semiconductor switching elements 231 may be connected in series. If a direction of controlling a current is limited, the elements may be configured to be directed in one direction only.

[0061] The arrestor 232 may be connected in parallel to each of the semiconductor switching elements 231 or to a plurality of the semiconductor switching elements 231, or two or more semiconductor circuit breaker 23 may be connected in series.

[0062] Although not explained with reference to FIG. 4 in the above, a similar configuration may be applied to the DC circuit breakers at the coupling point of four or more DC power transmission lines.

(Fourth Embodiment)

[0063] FIG. 5 is a diagram showing a configuration of a DC circuit breaker according to the fourth embodiment. Since a basic concept is the same as the configuration illustrated in FIG. 1, the constituent elements the same as or corresponding to those of the DC circuit breaker illustrated in FIG. 1 will be referred to by the same reference symbols as those used in FIG. 1.

[0064] The DC circuit breaker is configured in such a manner that two reactors 22 and two semiconductor circuit breakers 23 are alternately connected in each series circuit 2. One end of each of the mechanical-contact current disconnectors 32 is connected to each of the middle points e, f, and g of the series circuits 2, and all the other ends of the mechanical-contact current disconnectors 32 are connected to each other at the contact point j.

[0065] One end of each of the mechanical-contact current disconnector 33 is connected to the joint point of the semiconductor circuit breaker 23 and the reactor 22 not connected to one the middle points e, f, g of the series circuits 2, and the other end is connected to the coupling point of the reactor 22 and the semiconductor circuit breaker 23 of an adjacent series circuit 2. At this time, the mechanical-contact current disconnector 33 connects the joint points of the reactors 22 and the semiconductor circuit breakers 23 belonging to the series circuits 2 bifurcated from the same DC power transmission line.

[0066] A not-illustrated control circuit controls an ON/OFF operation of all the semiconductor circuit breakers 23 of the series circuits 2 in accordance with a time when a steady operation is carried out or when a fault occurs in any of the power transmission lines.

[0067] The control circuit also controls an ON/OFF operation of the mechanical-contact current disconnectors 32 and 33 in the wire connection circuit 3.

[0068] The current interruption operation in the present DC circuit breaker is similar to that in the third embodiment, and even when a fault occurs in any of the DC power transmission lines, the DC power transmission line where the fault has occurred can be cut off.

[0069] According to the present embodiment, compared to the configuration in the third embodiment, required insulation resistance is decreased as a voltage applied to the mechanical-contact current disconnectors 32 and 33 is low. For this reason, it is possible to use mechanical-contact current disconnectors 32 that are inexpensive and slow in opening/closing by shortening an insulation distance, thereby constructing a DC circuit breaker with a lower cost.

[0070] A bridge circuit consisting of a series circuit 2 and a wire connection circuit 3 may be configured as a multiple-stage circuit. The current interruption operation in the present DC circuit breaker is similar to that in the fourth embodiment, and even when a fault occurs in any of the DC power transmission lines, the DC power transmission line where the fault has occurred can be cut off.

[0071] A multiple-stage bridge circuit further lowers a voltage applied to the mechanical contact type current disconnector, and thus, it becomes possible to construct a DC circuit breaker with a further lower cost by using a mechanical contact type current disconnector that is cheap and slow in in opening/closing.

[0072] The series circuits 2 and the wire connection circuits 3 may be replaced with the constituent elements of the first embodiment to configure a DC circuit breaker in a similar manner.

[0073] For example, it is possible to replace the series circuits 2 and the wire connection circuits 3 shown in FIG. 5 with the series circuits 2 and the wire connection circuits 3 shown in FIG. 1. In this case, for example, four or more mechanical contact type current disconnectors 21 may be directly connected in the series circuit 2.

[0074] As described in detail in the above, according to at least one embodiment, it is possible to realize a low-cost and compact DC circuit breaker having a lower number of components and provided at a coupling point of a plurality of DC power transmission lines, while being able to interrupt a fault current at high speed.

[0075] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope. Indeed, the embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions, and changes in the form of the embodiments described herein may be made without departing from the spirit of the invention. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the invention.

Claims

1. A direct current circuit breaker that is provided at a coupling point where three or more direct current power transmission lines are electrically coupled in a direct current power transmission line network, the breaker **characterized by** comprising:

   three or more series circuits, each of the series circuit being connected to ends of two different direct current power transmission lines, and including a serial connection of two or more current disconnectors; and
   three or more wire connection circuits, one end of each of the wire connection circuits being connected to a middle point of the series circuit, and another end being connected to one point where other ends of the wire connection circuits are connected to, each of the wire connection circuits including a commutation circuit in which a current is commutated.

2. The direct current circuit breaker according to claim 1, **characterized in that**
   during a steady operation, each of the current disconnectors is operated in an on state, and
   when a system fault occurs in the direct current power transmission line network, some of the current disconnectors are turned off, so that a current flowing between a direct current power transmission line where the fault occurs and other direct current power transmission lines flows in the current disconnector, the wire connection circuit, and the current disconnector in this order,
   the commutation circuit included in the wire connection circuit is controlled so that a current flowing in the direct current power transmission line where the fault occurs is decreased to zero, and the current disconnector connected to the direct current power transmission line where the fault occurs is turned off in a zero current state.

3. The direct current circuit breaker according to claim 1 or 2, **characterized in that**
   each of the series circuits includes a serial connec-

tion of a plurality of current disconnectors between the middle point and the ends of the two different direct current power transmission lines, and
the direct current circuit breaker further comprising three or more wire connection circuits, each of the wire connection circuits including a commutation circuit that connects coupling points of the plurality of current disconnectors in each series circuit that is bifurcated from an end of the direct current power transmission line.

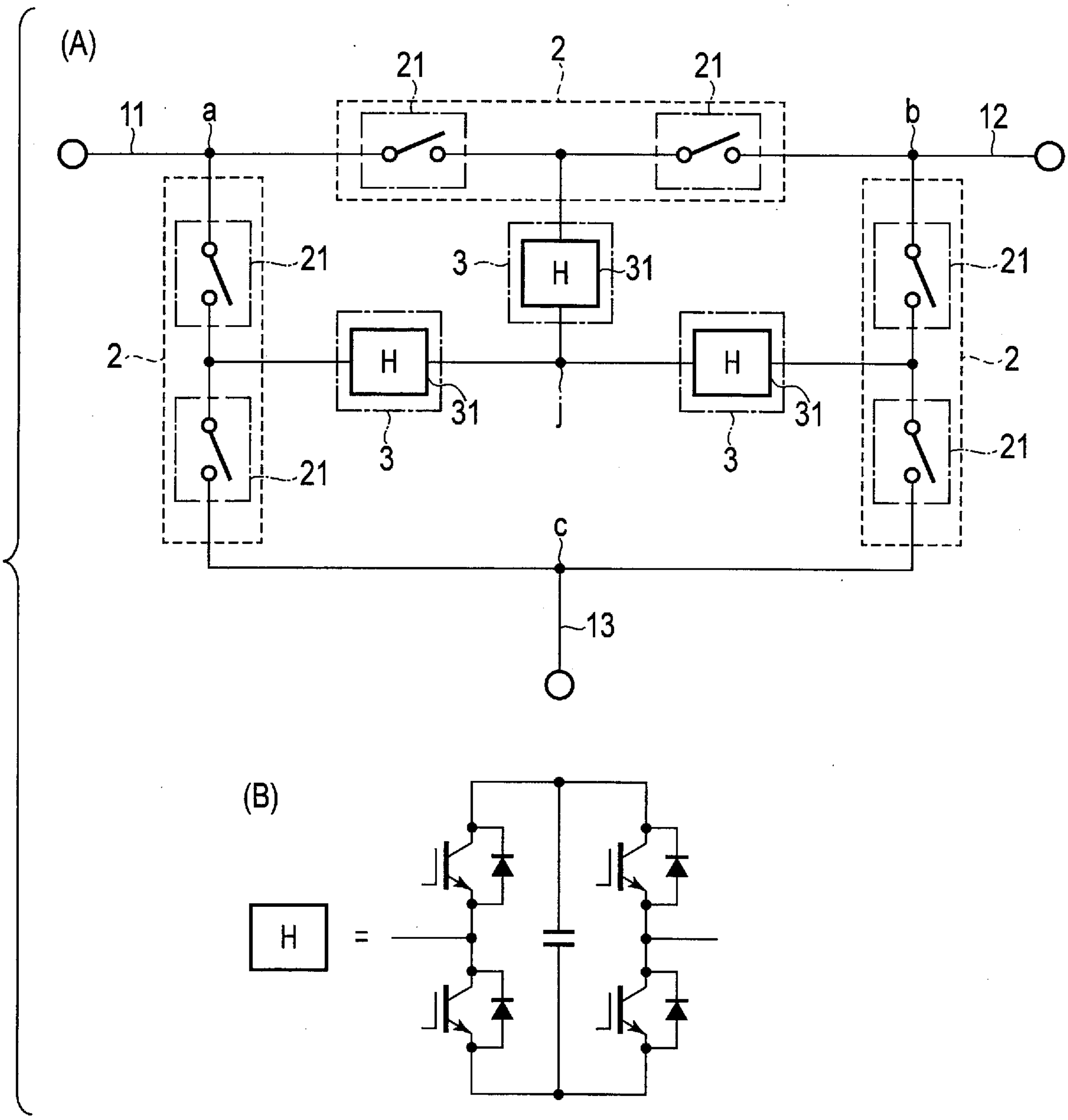
4. A direct current circuit breaker that is provided at a coupling point where three or more direct current power transmission lines are electrically coupled in a direct current power transmission line network, the breaker **characterized by** comprising:

three or more series circuits, each of the series circuits being connected to ends of two different direct current power transmission lines, and including a serial connection of two or more elements which includes a commutation means; and
three or more wire connection circuits, each of the wire connection circuits including a current disconnector, one end of the current disconnector being connected to a middle point of the series circuit, and another end being connected to one point where other ends of the current disconnectors are connected to.

5. The direct current circuit breaker according to claim 4, **characterized in that**
during a steady operation, each of the current disconnectors is operated in an on state,
when a system fault occurs, the commutating means is operated in such a manner that a current of the current disconnector of the wire connection circuit is decreased to zero, wherein a current flowing in the direct current power transmission line where the fault occurs flows in the commutating means, and
the current disconnector is turned off in a zero current status, wherein a current flowing in the direct current power transmission line where the fault occurs flows in the current disconnector.

6. The direct current circuit breaker according to claim 4 or 5, **characterized in that**
each of the series circuits includes a serial connection of a plurality of elements which includes the commutating means between the middle point and the ends of the two different direct current power transmission lines, and
the direct current circuit breaker further comprising three or more wire connection circuits, each of the wire connection circuits including a current disconnector that connects coupling points of the plurality of elements which includes the commutating means in each series circuit that is bifurcated from an end of the direct current power transmission line.

7. The direct current circuit breaker according to claim 4 or 5, **characterized in that** the series circuit includes a reactor and a semiconductor circuit breaker.



F I G. 1

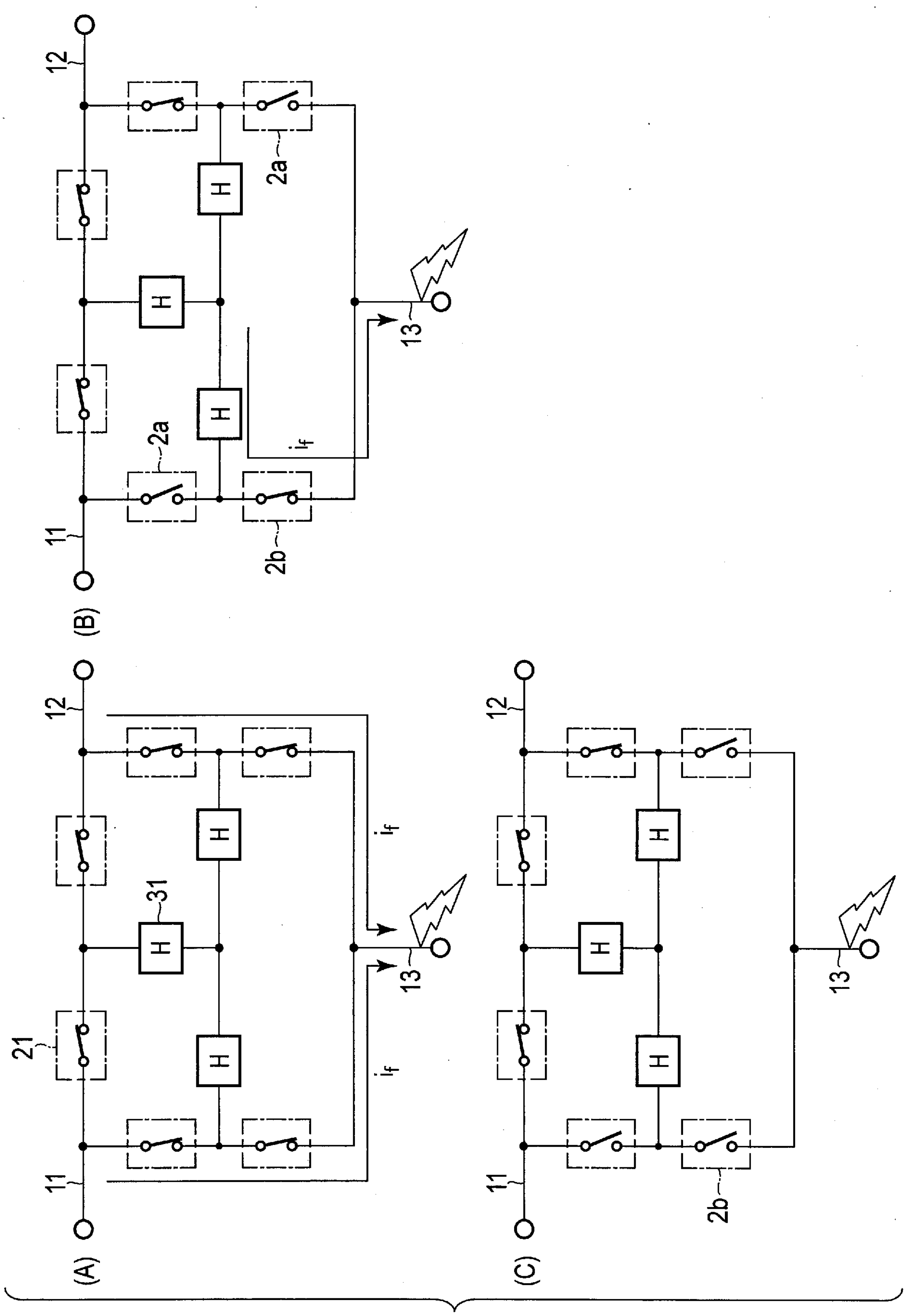


FIG. 2

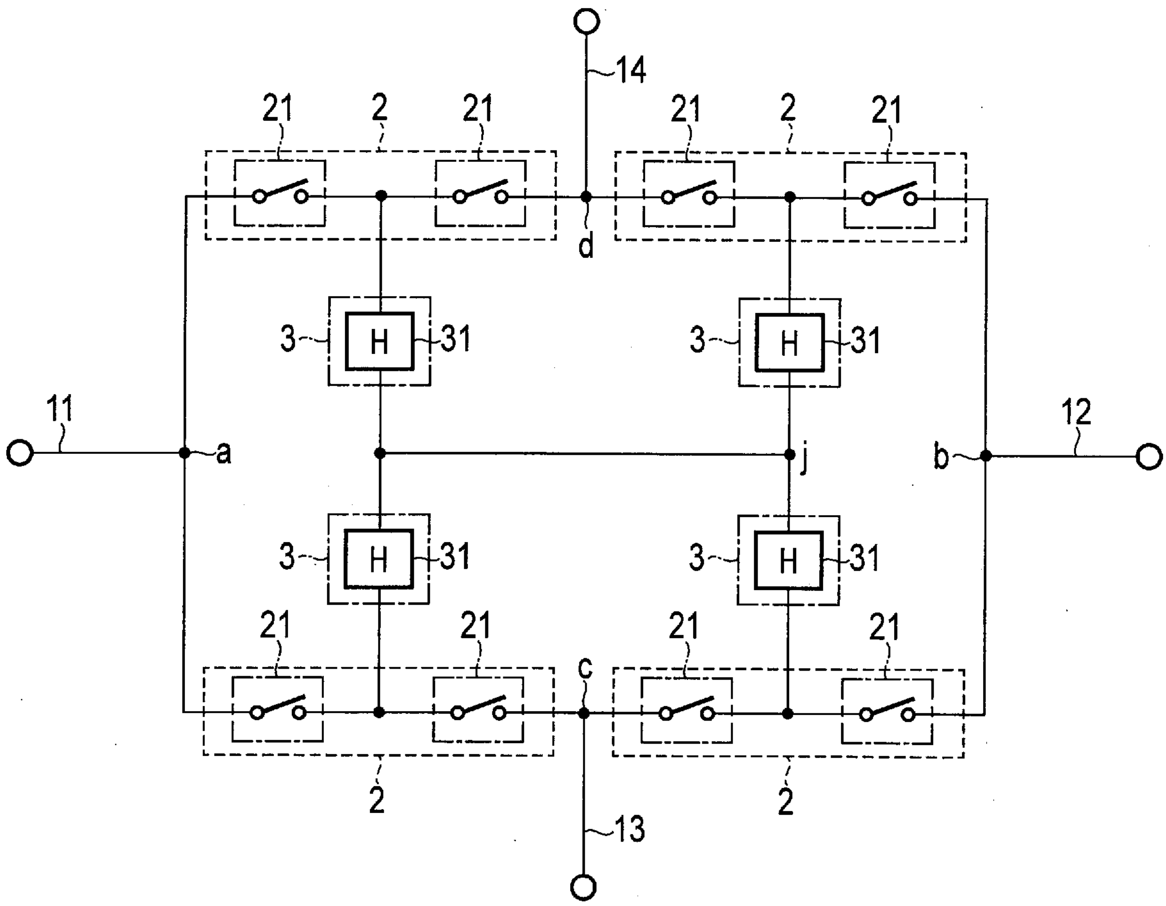
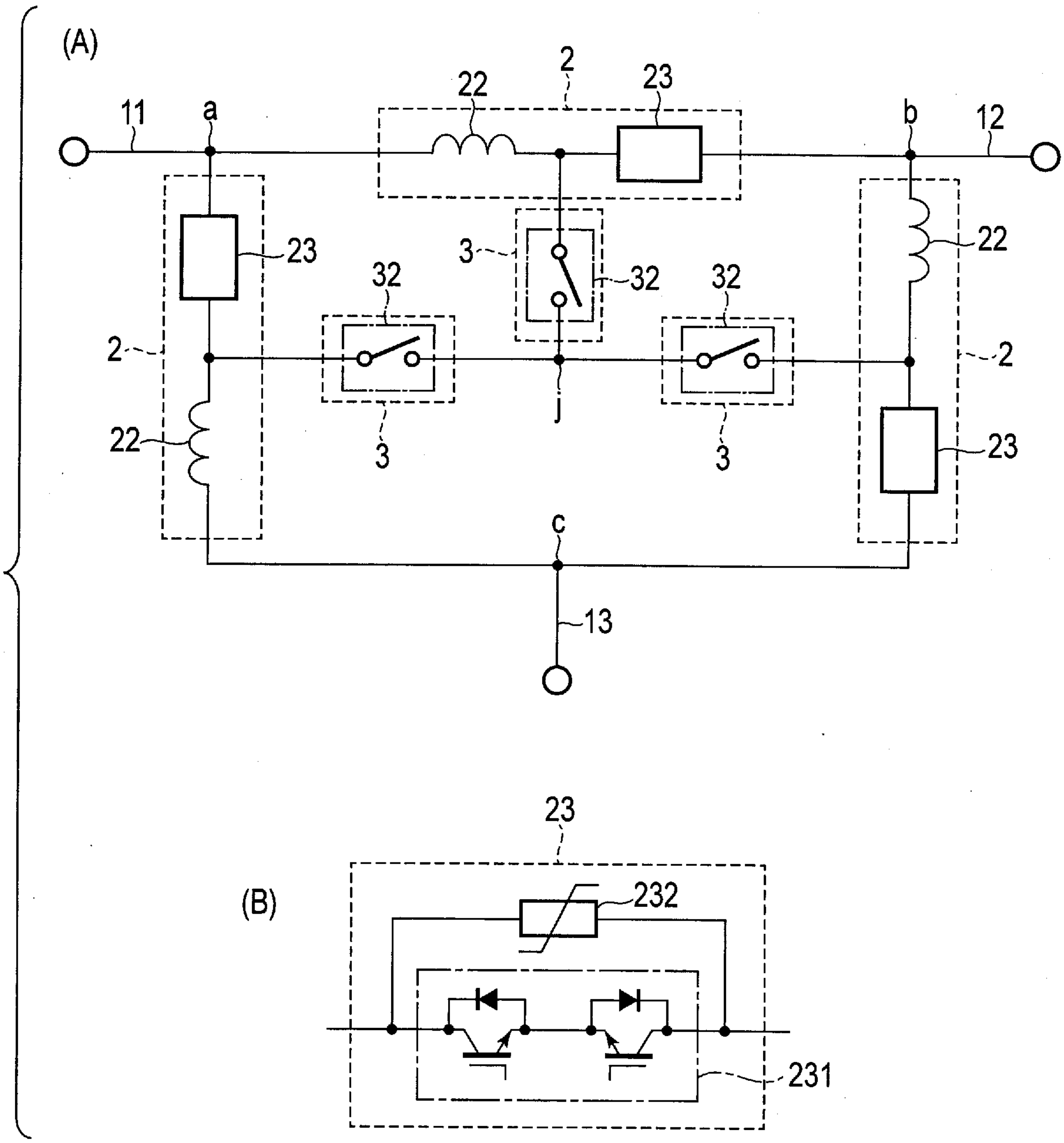


FIG. 3



F I G. 4

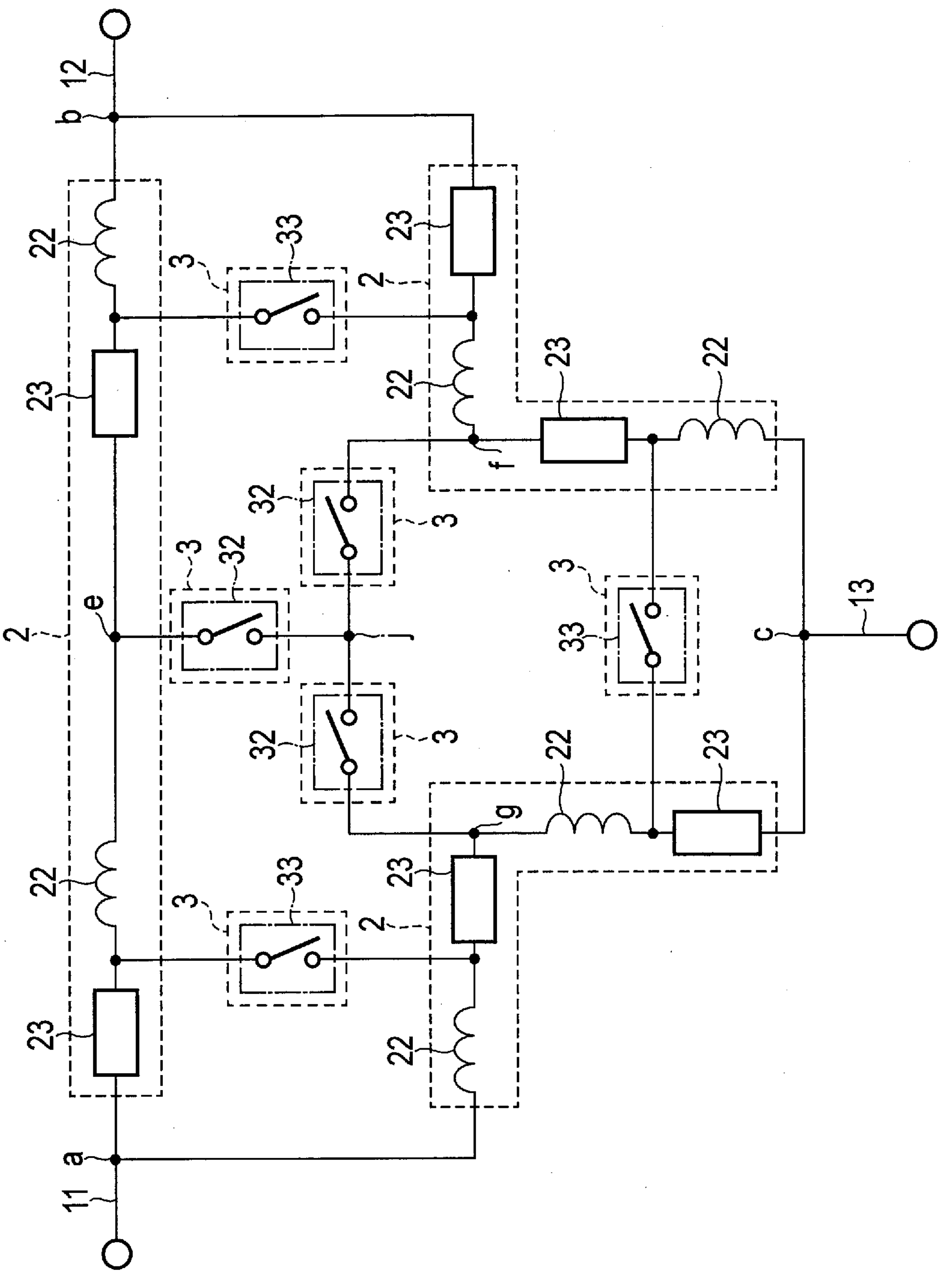
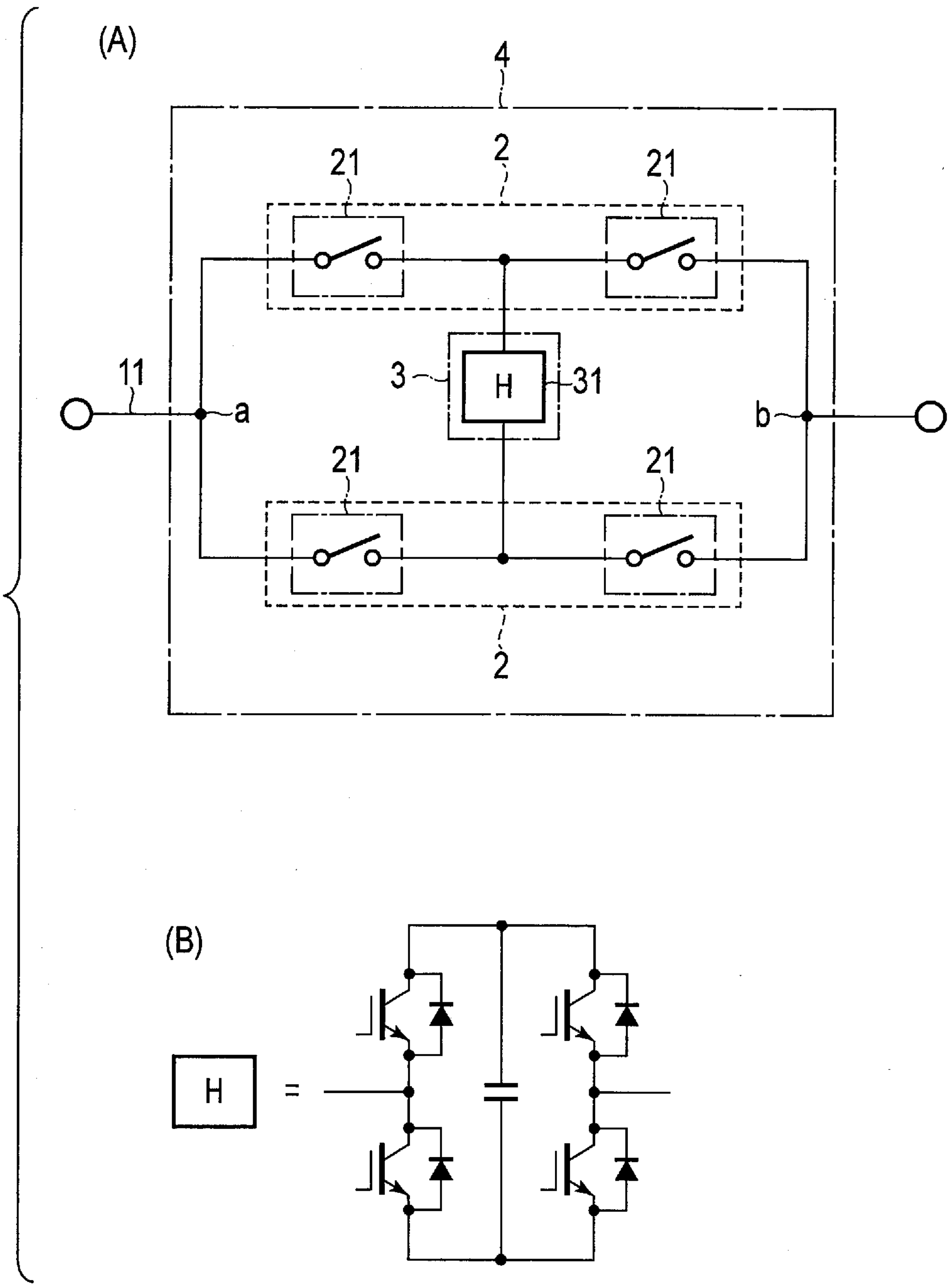


FIG. 5



F I G. 6

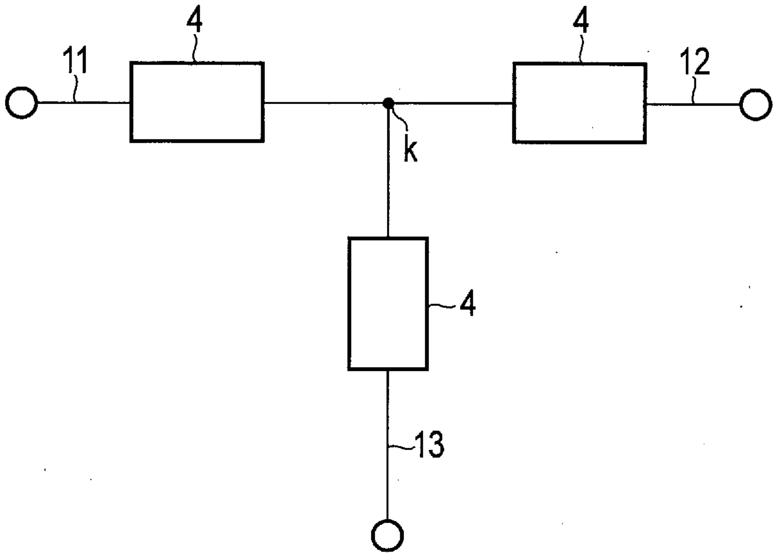


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/066018

A. CLASSIFICATION OF SUBJECT MATTER
H01H33/59(2006.01)i, *H01H9/54*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01H33/59, H01H9/54

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO 2014/094847 A1 (SIEMENS AG), 26 June 2014 (26.06.2014), page 17, line 36 to page 18, line 32; fig. 8 & US 2015/0333496 A1 paragraph [0045]; fig. 8 & EP 2907152 A1 & CN 104838462 A	1,2 3-7
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 061995/1987(Laid-open No. 033537/1988) (Fuji Electric Co., Ltd.), 04 March 1988 (04.03.1988), pages 2 to 3; fig. 1 (Family: none)	1,2

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 2016 (26.08.16)	06 September 2016 (06.09.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/066018

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2014-235834 A (Toshiba Corp.), 15 December 2014 (15.12.2014), paragraphs [0022] to [0035]; fig. 1 (Family: none)	1,2
A	JP 57-090830 A (Tokyo Shibaura Electric Co., Ltd.), 05 June 1982 (05.06.1982), page 3, upper left column; fig. 5 (Family: none)	1-7

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