



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
10.11.2010 Bulletin 2010/45

(51) Int Cl.:
H01H 31/00 (2006.01) H02B 13/035 (2006.01)

(21) Application number: **09159681.7**

(22) Date of filing: **07.05.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR

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(54) **Arrangement, substation, operating method and use of a grounding switch for protecting an electrical circuit against short-line faults**

(57) The invention relates to an arrangement (1) for protecting an electrical circuit from damage caused by a short-line fault, comprising a circuit breaker (2) that connects a generator or busbar (4) with a line (5), wherein a grounding switch (3) is provided that connects the line (5) to ground. The invention further relates to a method for operating such an arrangement that comprises the steps of initially setting the circuit breaker (2) into a closed

state and the grounding switch (3) into an open state, and upon detection of a short-line fault opening of the circuit breaker (2) and closing of the grounding switch (3). The invention still further relates to the use of a grounding switch (3) together with a circuit breaker (2) to protect an electrical circuit from damage caused by a short-line fault by suppressing transient recovery voltages.

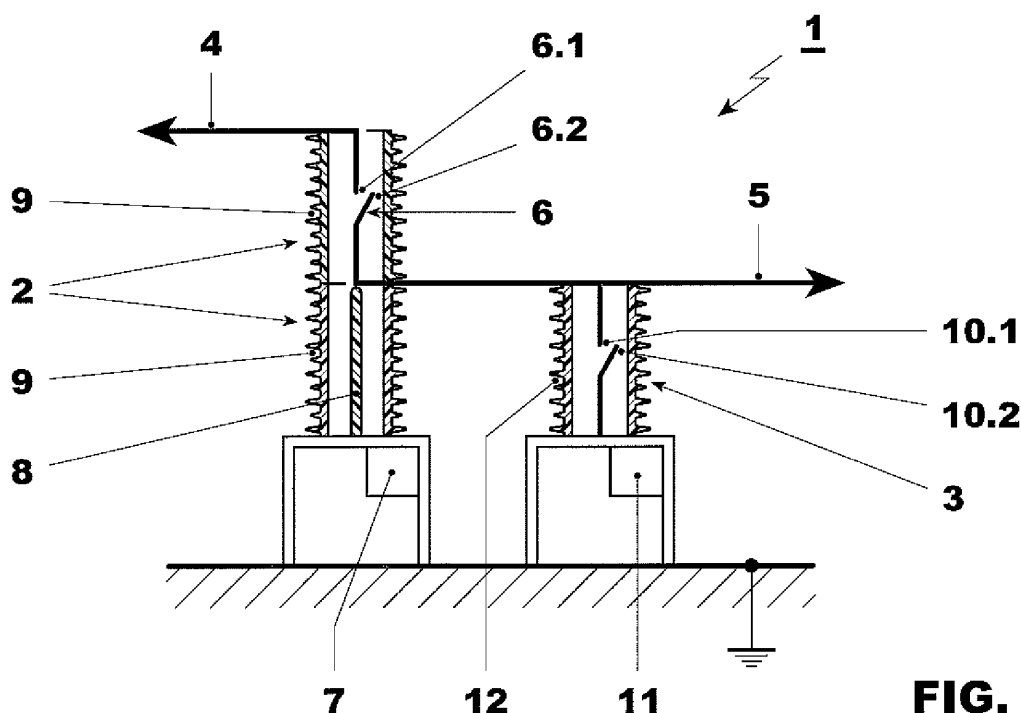


FIG. 1

Description

Technical field

[0001] The invention relates to an arrangement for protecting an electrical circuit from damage caused by a short-line fault, a method for operating such an arrangement and the use of a grounding switch to protect an electrical circuit from damage caused by a short-line fault. The invention can be applied indoor or outdoor. The electrical circuit in question is in particular an electrical power transmission and distribution network that is AC-driven.

Background

[0002] Circuit breakers are usually employed in electrical circuits for protection against damage caused by overload or short circuit. Upon detection of a fault condition the circuit breaker immediately discontinues the electrical flow. Circuit breakers are rated by the normal operating current they are expected to carry and by the maximum short circuit current that they are able to safely interrupt among others. When the electrical contacts of a circuit breaker open to interrupt a short circuit current, typically an arc forms between the opened contacts. To suppress and extinguish the arc usually vacuum, air, an inert gas, or oil is used. As high-voltage circuit breakers often sulfur hexafluoride (SF₆) circuit breakers are used, in particular with thermal blast chambers or self-blast chambers. For an overview of circuit breakers see among others

http://en.wikipedia.org/wiki/Circuit_breaker.

[0003] From US 7,333,316 B1 a transient voltage protection circuit is known for use with AC circuits that comprises a transient suppressor circuit with a threshold thyristor connected in series with a capacitor.

[0004] US 5,821,496 A discloses a method and an insulation switch gear for controlling transient recovery voltage wherein a saturable reactor having a capacity connected in parallel is connected to a gas circuit breaker in series, and wherein an LC resonance is produced between a self-inductance L of the reactor and an electrostatic capacitance C of the parallel capacitor.

[0005] In WO 2007/068686 A1 an electric switchgear with an interrupter unit is disclosed. Capacitive coated post insulators are provided so as to support the interrupter unit in an insulating manner. The capacitive coating can be used to dampen a travelling voltage wave incoming during an interruption of a short-line fault.

[0006] DE 31 30 643 A1 discloses that in the event of a short-line fault on an overhead line a switch bypasses in current-dependent or voltage-dependent manner a high-frequency inductor coil disposed in the earth connection of the capacitive voltage transformer or of the coupling capacitor and a spark gap short circuits a high-frequency line trap disposed in the overhead line.

[0007] JP 3-190021 A and JP 3-190028 A disclose the provision of a magnetic member with a specific B-H char-

acteristic for improving the breaking property in the event of a short-line fault.

Summary of the invention

[0008] It is an object of the invention to provide an arrangement for protecting an electrical circuit, that comprises a circuit breaker, from damage caused by a short-line fault, wherein the circuit breaker can be realised constructively simpler and less expensive as for the case of the circuit breaker being used on its own for protection of the electrical circuit. It is a further object of the invention to provide a method for operating such an arrangement.

[0009] In order to implement this object and still further objects of the invention, which will become more readily apparent as the description proceeds, an arrangement for protecting an electrical circuit from damage caused by a short-line fault is provided that comprises a circuit breaker, that connects a generator or a busbar of the electrical circuit with a line, in particular an overhead line, of the electrical circuit, and that further comprises a grounding switch that connects the overhead line to ground (also called: earth). A short-line fault is understood as a short circuit fault to ground occurring at a place in the electrical network that is typically a few hundred metres to a few kilometres afar from the circuit breaker. The electrical circuit is in particular an electrical power transmission and distribution network and the circuit breaker is in particular a high-voltage circuit breaker, preferably a gas circuit breaker, in particular a sulfur hexafluoride (SF₆) circuit breaker.

[0010] A further aspect of the invention relates to a high-voltage or medium-voltage substation for energy transmission or energy distribution networks, that comprises such an arrangement for protecting an electrical circuit by combined and time-coordinated use of a circuit breaker and grounding switch, as disclosed in detail in this application.

[0011] According to the method of the invention for operating the arrangement of the invention the circuit breaker is initially set into a closed state (also called on-state), i.e. it has initially closed contacts, and the grounding switch is initially set into an open state (also called off-state). Thus, during normal operation the circuit breaker is closed and the grounding switch is open. Upon detection of a short-line fault the circuit breaker is opened and the grounding switch is closed, wherein the grounding switch preferably closes a certain amount of time before the minimum breaking time of the circuit breaker is reached, i.e. slightly before the circuit breaker has fully completed circuit interruption.

[0012] Closing of the grounding switch initiates an artificial terminal fault close to the circuit breaker, i.e. the artificial terminal fault in particular occurring less than one hundred metres, preferably less than 10 metres, afar from the circuit breaker, with the short circuit current through the circuit breaker being basically 100% of the possible short circuit current of the electrical circuit in

question as the circuit breaker is directly connected to ground with small impedance via the closed grounding switch. The grounding switch is preferably located about 10 m, more preferred 5 m, most preferred 1 to 2 metres from the circuit breaker. Closing of the grounding switch leads advantageously to a clipping/suppressing of the relatively steep recovery voltage transients that typically appear after interruption of the short circuit current by opening the circuit breaker and are caused by the line-side travelling waves. By clipping/suppressing the voltage transients from the line side the overall thermal interruption stress is decreased such that the requirements for the circuit breaker of the arrangement of the invention can be lowered, i.e. a circuit breaker with simpler design and lower costs can be employed as if no grounding switch were employed. Thermal interruption takes place a few microseconds after current zero and the short-line fault is typically the most difficult fault to handle with respect to thermal interruption performance. By closing of the grounding switch the short-line fault is hence advantageously transformed into a terminal fault which can be much easier handled by the circuit breaker, i.e. imposes much less requirements on the employed circuit breaker, as the slope of the transient recovery voltage is considerably less steep for a terminal fault than for a short-line fault.

[0013] If a high-voltage SF6 circuit breaker with self-blast chambers is employed then the circuit breaker can advantageously be dimensioned to provide only a relatively small pressure build-up at highest possible currents. For a high-voltage SF6 circuit breaker with self-blast chambers the typically required pressure for extinguishing the arc between its contacts to interrupt the short circuit current in case of a short-line fault is around several ten bar if the circuit breaker is used alone. With the use of a grounding switch the required pressure for extinguishing the arc can advantageously be much less than 10 bar (< 10 bar). As the short-line fault is converted into an artificial terminal fault (i.e. in particular a T100a fault - an asymmetrical 100% breaker terminal fault) there is basically no risk of overheating due to hot inert gas of the circuit breaker. If a puffer-type circuit breaker is employed, it can be dimensioned to only provide for a small maximum pressure and thus only a small dimensioned actuator means/drive is required.

[0014] The grounding switch is only required to close on a short-circuit current and not to open as the circuit breaker. Hence, it can be of corresponding simpler design with less intricate dimensioning of its components than the circuit breaker, while still supporting the circuit breaker in interrupting the short circuit current.

[0015] The grounding switch can in particular be used together with circuit breakers with a rated voltage of more than 245 kV and a rated current of more than or equal to 63 kA, for example with LTB (life tank breaker) circuit breakers. The large parallel capacitors of the breakers can be omitted and/or a single pole breaker can be used instead of a double/two pole breaker in T-arrangement.

Brief description of the drawings

[0016] Further advantageous features and applications of the invention can be found in the dependent claims as well as in the following description of the drawings illustrating the invention. In the drawings like reference signs designate the same or similar parts throughout the several features of which:

- 10 Figure 1 shows a schematic drawing of an arrangement of the invention, and
Figure 2 shows a schematic drawing of a grounding switch employed in an arrangement of the invention.

15 Embodiments of the invention

[0017] Figure 1 shows an arrangement 1 according to the invention with a circuit breaker 2 and a grounding switch 3. The circuit breaker 2 connects via corresponding terminals a generator or busbar side 4 of an electrical circuit or network with the line side 5 of the electrical circuit or network. The grounding switch 3 connects the line side 5 to ground. During normal operation the circuit breaker 2 is closed and the grounding switch 3 is open, i.e. current flow from the generator or busbar side 4 to the line side 5 is uninterrupted, while current flow from the line side to ground is interrupted. The grounding switch 3 preferably comprises control and operating means for closing the grounding switch 3 in order to transform a short-line fault occurring on the line side 5 into a terminal fault of the circuit breaker 2.

[0018] The circuit breaker 2 and the grounding switch 3 are preferably not arranged in the same housing but may of course be so if appropriate. The grounding switch 3 may be coupled mechanically to the circuit breaker 2 but preferably both, the circuit breaker 2 and the grounding switch 3, have separate actuator means 7, 11 that are described below.

[0019] The circuit breaker 2 comprises an interrupter 6 with two contacts 6.1 and 6.2, the interrupter 6 being located in the current path from the generator or busbar side 4 to the line side 5. At least contact 6.2 is movable. The circuit breaker 2 further comprises actuator means 7 for moving the one or more movable contacts 6.1, 6.2 of the interrupter 6 such that the contact 6.2 touches the contact 6.1, thereby closing the circuit breaker 2 (i.e. its interrupter 6), and for separating the contact 6.2 from the contact 6.1, thereby opening the contact breaker 2 (i.e. its interrupter 6). The actuator means 7 are preferably given by a stored-energy spring actuator. The actuator means 7 are on ground potential. The movable contact 6.2 is preferably connected to the actuator means 7 via an insulator rod 8 that provides insulation of the interrupter 6 against ground. By moving the insulator rod 8 with the actuator means 7, the contact 6.2 is moved to and from the contact 6.1. The circuit breaker 2 comprises an outer insulator 9 filled with an inert gas, in particular SF6, in which the interrupter 6 and the insulator rod 8 are her-

metically enclosed. Alternatively, the outer insulator 9 and the contacts 6.1 and 6.2 may be placed in an alternative insulation and interruption medium, e.g. carbon dioxide (CO₂), synthetic air or vacuum. Of course, different circuit breaker designs may be employed. Preferably a sensor (not shown) is provided for detecting a short-line fault, i.e. its occurrence. The sensor can form part of the circuit breaker 2.

[0020] The grounding switch 3 is designed such that it can provide a given pre-defined basic insulation level (BIL) in its open state and such that it withstands pre-defined maximum possibly occurring transient voltages in open condition/state. The basic insulation level (BIL) is defined as the insulation capability of an element of electrical equipment (here: the grounding switch 3) to withstand specified voltage surges (BIL voltage).

[0021] The grounding switch 3 comprises two contacts 10.1 and 10.2 with at least the contact 10.2 being movable. The contacts 10.1 and 10.2 can be arranged as plug and tulip (as shown in Fig. 2) or as head-to-head (not shown) in a current path from the line side 5 of the electrical circuit/network to ground. Actuator means 11 are provided for moving the contact 10.2 such that it touches the contact 10.1, thereby closing the grounding switch 3, and for separating the contact 10.2 from the contact 10.1, thereby opening the grounding switch 3, i.e. for providing fast opening and closing of the grounding switch 3. The actuator means 11 are on ground potential and are preferably given by a stored-energy spring actuator. The grounding switch 3 preferentially comprises an outer insulator 12 filled with an inert gas, preferably SF₆, in which the contacts 10.1 and 10.2 are hermetically enclosed (in the following: SF₆ grounding switch). Alternatively, the outer insulator 12 might be filled with an alternative insulation medium, e.g. CO₂ and/or synthetic air. A possible detailed version of the grounding switch 3 is shown in Figure 2 with the actuator means 11 being not depicted for simplicity. For controlling the electrical field inside the grounding switch 3 and in the vicinity of the contacts 10.1 and 10.2 each contact 10.1, 10.2 has assigned to it an element 13 for electrical field control, in particular an electrical shield, that preferably cylindrically surrounds the respective contact 10.1, 10.2.

[0022] Of course, different grounding switch designs may be used. The grounding switch 3 may, for example, comprise or further comprise a vacuum switch or/and a semiconductor switch that are preferably arranged in series to the contacts 10.1 and 10.2 that constitute a mechanical switch. If both, a vacuum switch and a semiconductor switch, are provided, they are preferentially arranged in series. As semiconductor switch e.g. a IGBT-(insulated gate bipolar transistor) module may be used.

[0023] A control unit (not shown) is provided for tripping and resetting the circuit breaker 2 and the grounding switch 3 in dependence on the occurrence of a short-line fault, in particular if the sensor gives a corresponding output.

[0024] Initially, i.e. during normal operation, the circuit breaker 2 is closed and the grounding switch 3 is open. If - preferably by the above-mentioned sensor - a fault in form of an over-current/a short circuit current is detected and if the direction of the fault is line-side (as opposed to generator or busbar side) and if furthermore the distance from circuit breaker 2 to the fault indicates that a short-line fault occurred, preferentially only then the method of the invention is employed. Upon detection of a short-line fault the control unit generates and transmits a trigger signal to the circuit breaker 2 to trigger the circuit breaker 2 to open. The minimum opening/breaking time of the circuit breaker 2, i.e. its interrupter 6, is for example approximately 40 ms. Preferably at the same time the control unit generates and transmits a further trigger signal to the grounding switch 3 to trigger the grounding switch 3 to close. The maximum closing time of the grounding switch 3 is preferably lower than the minimum breaking time of the circuit breaker 2, so that the grounding switch 3 closes shortly before the circuit breaker 2 has interrupted. The grounding switch 3 preferentially closes approximately 2 ms before the minimum breaking time of the interrupter 6/the circuit breaker 2 is reached to account for/compensate possible jitter in the grounding switch 3 and the interrupter 6 of the circuit breaker 2. If the grounding switch 3 comprises a semiconductor switch then its maximum closing time can be chosen even closer to the minimum breaking time of the interrupter 6/circuit breaker 2 due to the speed of the semiconductor switch. The grounding switch 3 preferentially closes before the first current zero that the circuit breaker 2 could interrupt.

[0025] It is emphasized that the fast reaction times needed for the grounding switch 3 in order to transform the short-line fault into a terminal fault cannot be achieved with conventionally available mechanical grounding switches. Therefore, the grounding switch 3 of the invention must have a fast mechanical actuator means 11 and/or the support of a series-connected vacuum or semiconductor switch. The closing time of the grounding switch 3 between detection of the short-line fault and the closing of the grounding switch 3 shall be shorter than the interruption time of the circuit breaker 2.

[0026] In the event of a short-line fault the grounding switch 3 stays in the closed state to carry the current caused by the fault up to a certain amount of time until the circuit breaker 2 has interrupted. This is in the order of the 2 milliseconds mentioned above, but preferentially also one half-wave longer, i.e. in 50 Hz networks approximately 12 milliseconds in total.

[0027] Closing of the grounding switch 3 initiates an artificial circuit breaker terminal fault with the short circuit current running through the circuit breaker 2 being basically 100% of the possible short circuit current of the electrical circuit in question as the circuit breaker 2 is via the closed grounding switch 3 directly connected to ground with small impedance. Depending on the topology of the electrical circuit/network in question and on the time in-

stant of closing of the grounding switch, i.e. the phase angle of the short circuit current at the closing time instant, the current through the circuit breaker 2 may include a DC component.

[0028] The circuit breaker 2 interrupts the short circuit current by extinguishing the arc between its contacts 6.1 and 6.2. As discussed above the pressure, that is required at least for gas (e.g. SF₆) filled circuit breakers within the circuit breaker 2 for interrupting the short circuit current caused by a circuit breaker terminal fault (and hence the artificial terminal fault into which the short-line fault is converted by closing the grounding switch 3), is much lower than the pressure that would be required to extinguish the arc caused by a short-line fault, if actually no grounding switch 3 were provided.

[0029] After interruption of the short circuit current has taken place by the interrupter 6 of the circuit breaker 2, the grounding switch 3 opens again at a certain time instant. The grounding switch 3 is preferably triggered by the control unit to open again. This opening time instant is preferably chosen at a time at which the residual current in the line is gone and the line voltage is basically equal to zero, such that the opening takes place without current flow and voltage drop, the line being insulated by preferably two circuit breakers 2, one on each side of the place in the electrical circuit where the short-line fault occurred, and being grounded by the grounding switch 3 when the opening is initiated. Therefor the opening time instant is preferentially chosen such that the contact 10.2 has been moved so far by the actuator means 11 that the contacts 10.1 and 10.2 have reached its maximum distance or at least a distance that is sufficient to insulate the rated voltage - it not necessarily being required that the distance is sufficient to insulate an overvoltage or the BIL voltage - no later than at the maximum required O-C time interval (open-closed time interval) of the interrupter 6 of the circuit breaker 2. The O-C time interval of a circuit breaker 2 is defined as the time for an opened circuit breaker 2 to close to check if a temporary fault, e.g. as caused by a lightning stroke, has been resolved.

[0030] It is to be understood that while certain embodiments of the present invention have been illustrated and described herein, it is not to be limited to the specific embodiments described and shown.

List of reference numerals

[0031]

- 1 : arrangement
- 2 : circuit breaker
- 3 : grounding switch
- 4 : generator or busbar side
- 5 : line side
- 6 : interrupter
- 6.1 : contact
- 6.2 : contact
- 7 : actuator means

- 8 : insulator rod
- 9 : outer insulator
- 10.1 : contact
- 10.2 : contact
- 5 11 : actuator means
- 12 : outer insulator
- 13 : element for electrical field control

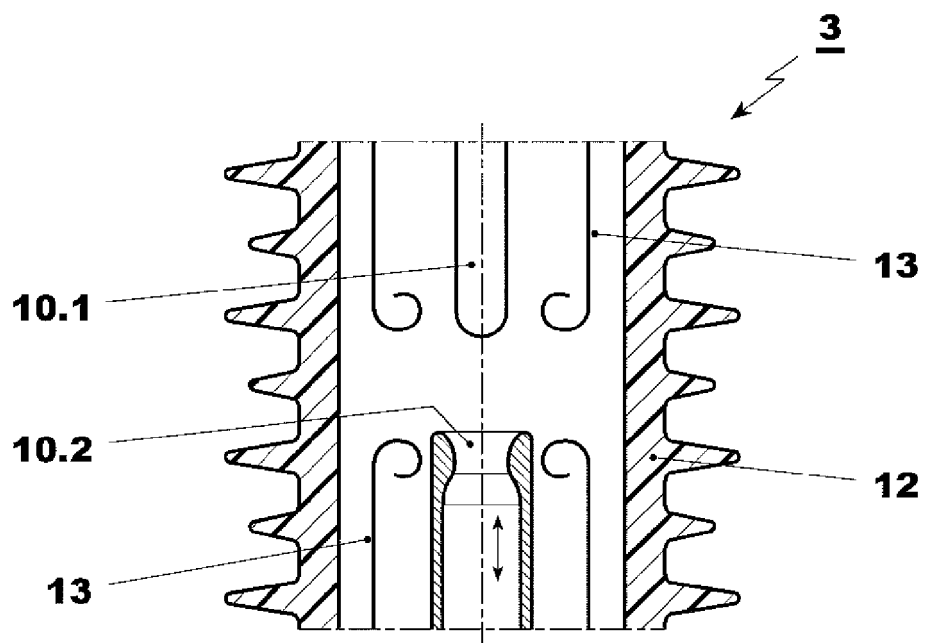
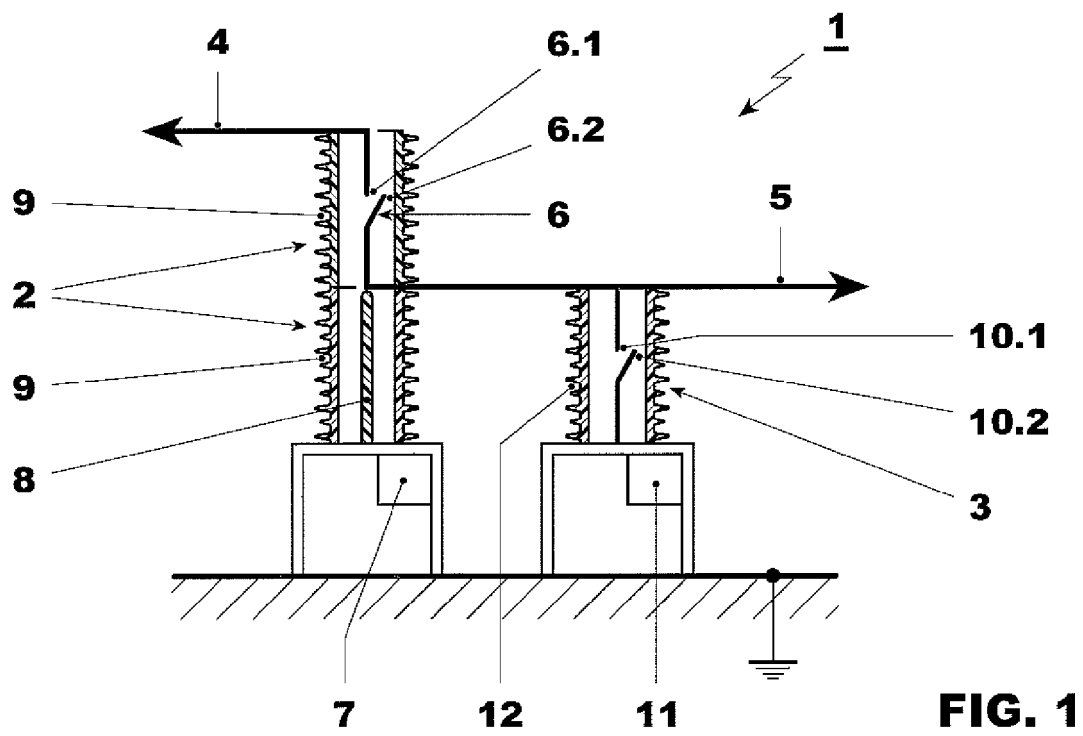
10 Claims

1. An arrangement for protecting an electrical circuit from damage caused by a short-line fault, comprising a circuit breaker (2) that connects a generator or busbar with a line (5), **characterized in that** a grounding switch (3) is provided that connects the line (5) to ground.
2. The arrangement of claim 1, wherein the grounding switch (3) comprises control and operating means for closing the grounding switch (3) in order to transform the short-line fault into a terminal fault of the circuit breaker (2).
3. The arrangement of one of the preceding claims, wherein a control unit is provided to trip and reset the circuit breaker (2) and the grounding switch (3).
4. The arrangement of one of the preceding claims, wherein one or more sensors are provided for detecting a short-line fault.
5. The arrangement of one of the preceding claims, wherein the grounding switch (3) is located less than 10 m, preferably less than 5 m, most preferably about 1 to 2 meters, away from the circuit breaker (2).
6. The arrangement of one of the preceding claims, wherein the circuit breaker (2) is of self-blast or puffertype and has a reduced pressure rating for extinguishing the arc between its contacts (6.1, 6.2), in particular has a pressure rating at the instant of current interruption below 10 bar.
7. The arrangement of one of the preceding claims, wherein parallel capacitors of the circuit breaker (3) are omitted, and/or a single pole circuit breaker (2) is used instead of a double pole circuit breaker, in particular instead of a double pole circuit breaker in a T-arrangement.
8. The arrangement of one of the preceding claims, wherein the grounding switch (3) comprises two contacts (10.1, 10.2) with at least one contact (10.2) being movable so that the contacts (10.1, 10.2) can touch each other or be separated from each other, and wherein the contacts (10.1, 10.2) are preferably placed in a vacuum, an inert gas, in particular sulfur

hexafluoride (SF₆), carbon dioxide (CO₂), and/or synthetic air.

9. The arrangement of claim 8, wherein the grounding switch (3) further comprises a vacuum switch or/and a semiconductor switch that is or are preferably arranged in series with the contacts (10.1, 10.2). 5
10. The arrangement of claim 8 or 9, wherein an element (13) for electrical field control, in particular an electrical shield (13), is assigned to each contact (10.1, 10.2) of the grounding switch (3). 10
11. The arrangement of one of the preceding claims, wherein the circuit breaker (2) and the grounding switch (3) are arranged in the same housing, and/or the grounding switch (3) is coupled mechanically to the circuit breaker (2). 15
12. The arrangement of one of the claims 1-10, wherein the circuit breaker (2) and the grounding switch (3) are arranged in separate housings and have separate actuator means (7, 11), which, in particular, comprise a stored-energy spring actuator on ground potential for the grounding switch (3). 20 25
13. A high-voltage or medium-voltage substation for energy transmission or energy distribution networks, comprising an arrangement for protecting an electrical circuit as claimed in one of the claims 1-12. 30
14. A method for operating an arrangement according to one of the claims 1-12, comprising the following steps of: 35
 - initially setting the circuit breaker (2) into a closed state and the grounding switch (3) into an open state, and
 - upon detection of a short-line fault opening the circuit breaker (2) and closing the grounding switch (3). 40
15. The method of claim 14, wherein the grounding switch (3) closes a certain amount of time, in particular approximately 2 milliseconds, before the minimum breaking time of the circuit breaker (2) is reached. 45
16. Use of a grounding switch (3) together with a circuit breaker (2) to protect an electrical circuit from damage caused by a short-line fault by suppressing transient recovery voltages. 50

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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 9681

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 11 84 837 B (SACHSENWERK LICHT & KRAFT AG) 7 January 1965 (1965-01-07) * the whole document *	1,13	INV. H01H31/00 H02B13/035
X	US 2005/103514 A1 (UTSUMI TOMOAKI [JP]; SATOU KAZUHIRO [JP]; SHIRONE TAKASHI [JP]; TSUCHI) 19 May 2005 (2005-05-19) * abstract; figures 1,2 *	1,13	
Y		10	
A	WO 90/13932 A1 (SIEMENS AG [DE]) 15 November 1990 (1990-11-15) * the whole document *	1	
Y	DE 39 01 180 A1 (PLASMATECH GMBH ELEKTROTECHNIS [DE]) 19 July 1990 (1990-07-19) * abstract *	6	
Y	US 3 192 440 A (PAUL BALTENSBERGER) 29 June 1965 (1965-06-29) * the whole document *	7	
A	EP 1 638 124 A1 (DE BIASI GIOVANNI [IT]) 22 March 2006 (2006-03-22) * paragraph [0007] *	9	TECHNICAL FIELDS SEARCHED (IPC) H01H H02B
X	US 2009/045171 A1 (MONTICH EDUARDO [AR]) 19 February 2009 (2009-02-19) * paragraphs [0044], [0052]; figures 2-5,7 *	1-4,8-9, 13-15 6-7,10	
Y			
4 The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 25 January 2010	Examiner Simonini, Stefano
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			



Application Number

EP 09 15 9681

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☒ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

1-4, 6-10, 13-15

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

EP 09 15 9681

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-4, 13

Invention 1 relates to the problem of controlling the system's operation during a short-circuit.

2. claims: 5, 11-12

Invention 2 relates to the disposition of the breaker and of the grounding switch.

3. claims: 6-10

Invention 3 relates to the details of the breaker.

4. claims: 14-15

Invention 4 relates to the problem of improving the operation method of a known breaker-earthing switch arrangement.

5. claim: 16

Invention 5 relates to a particular use of a known assembly.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 09 15 9681

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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25-01-2010

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
DE 1184837	B	07-01-1965	NONE	
US 2005103514	A1	19-05-2005	CN 1619745 A	25-05-2005
			JP 2005149926 A	09-06-2005
			KR 20050047460 A	20-05-2005
			TW 240292 B	21-09-2005
WO 9013932	A1	15-11-1990	AT 107804 T	15-07-1994
			DE 3915948 A1	15-11-1990
			DE 59006246 D1	28-07-1994
			DK 0471678 T3	07-11-1994
			EP 0471678 A1	26-02-1992
			ES 2056462 T3	01-10-1994
			GR 90100322 A	10-10-1991
			JP 2782474 B2	30-07-1998
			JP 4505245 T	10-09-1992
			NO 914415 A	12-11-1991
			PT 94020 A	29-11-1991
			SU 1836764 A3	23-08-1993
DE 3901180	A1	19-07-1990	NONE	
US 3192440	A	29-06-1965	BE 608159 A1	02-01-1962
			CH 380800 A	15-08-1964
			DE 1118858 B	07-12-1961
EP 1638124	A1	22-03-2006	NONE	
US 2009045171	A1	19-02-2009	WO 2009094048 A2	30-07-2009

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 7333316 B1 [0003]
- US 5821496 A [0004]
- WO 2007068686 A1 [0005]
- DE 3130643 A1 [0006]
- JP 3190021 A [0007]
- JP 3190028 A [0007]