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(54) **High-voltage electrical switchgear**

(57) The present invention relates to high-voltage electrical switchgear, of the type comprising an enclosure (1); at least one switching mechanism (8, 9) for operating switching means (4, 5), which allow performing breaking, connection, isolation and/or earthing functions; intensity and/or voltage measuring means (6, 7), as well as at least one control/protection device for activating the at least one switching mechanism (8, 9); the present invention fundamentally standing out in that the operation of the switching means (4, 5) depends on the reading of the measuring means (6, 7), such that at least one switching mechanism (8, 9) operates the opening of the switch-disconnector (5) in the case of currents equal to or less than the nominal current, whereas it operates the opening of the circuit breaker (4) before the opening of the switch-disconnector (5) in the case of currents greater than the nominal current.

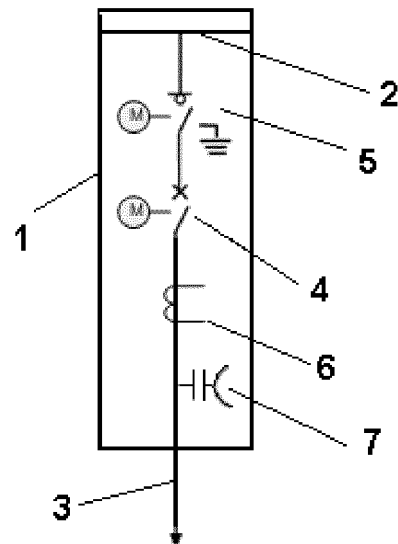


Fig. 2

Description

Object of the Invention

[0001] The field of application of the present invention is in electric power distribution installations, such as, for example, electric transformer sub-stations, distribution centers, sub-stations, etc., generally for electric circuit protection and switching, and it particularly relates to switchgear integrated inside an enclosure comprising a series of elements, among others, switching means which allow performing breaking and/or connection and/or isolation and/or earthing switching functions of the electric circuit.

Background of the Invention

[0002] The controlgear used in electric power distribution grids is installed in enclosures that are usually metallic, referred to as bays. Said switchgear comprises switching means that perform breaking-connection-isolation-earthing functions of the installation. Therefore, in the event of, for example, a fault in the distribution line, a cutoff due to works, maintenance or load distribution optimization, such switching means can be operated to obtain the desired electric power distribution, preventing consumers from being left without power or assuring protection of people and electrical equipment such as transformers, for example.

[0003] Said switching means are conventionally operated by means of a switching mechanism, which can be activated manually or automatically by a triggering mechanism which responds to a specific current. The switching mechanisms are what produce the operating force to perform breaking-connection-isolation-earthing functions of the installation.

[0004] On one hand, switching means formed by circuit breakers are known, which can consist of a vacuum bottle in which there is housed a pair of electric contacts, a fixed contact and a moving contact, which moves due to the operation of said switching mechanism, to perform breaking-connection functions of the corresponding electric circuit.

[0005] The problem with known vacuum switches is that the separation between the moving and fixed contacts in an open circuit situation is not acceptable because it does not assure the isolation function since the dielectric medium in which they act is the bottle vacuum. One usual solution is to include a disconnecter that opens/closes the circuit in series with the bottle to perform said isolation function efficiently. On the other hand, disconnecters are also used and earthing functions are also usually required of them. Disconnecters are known to be formed by two contacts which can come together for all the current to pass or to leave a physical separation established by the safety standard or the manufacturer to prevent the passage of the current. In the case of disconnecters with an included earthing function, they com-

prise an additional contact, specifically an earthing contact. However, said disconnecters do not perform the functions of the switch, i.e., cutting off the current when the circuit is under a load (nominal current), cutting off currents that are less than the nominal current or cutting off fault currents due to a surge. This entails the drawback that the assembly formed by the switch and its switching mechanism is forced to perform a number of switching operations, thereby reducing the electrical and mechanical endurance of the assembly.

[0006] The order of actuating switching means today when performing the opening (breaking)-isolation-earthing functions of the electric circuit is that in response to a fault the circuit breaker (4) cuts off the current and then the disconnecter (10) opens the circuit, the circuit thereby being isolated, as shown in Figure 1. Once isolated, the earthing disconnecter (10) then earths the electric circuit. The predominant philosophy concerning the order of actuating the switching means in the connecting operation is that first the disconnecter (10) closes the circuit (the disconnecter closes the circuit not under a load) and then closes the switch (4), said switch withstanding all the thermal and electrodynamic stresses generated due to the short-circuit caused in the closing of the contacts, which stresses are produced by the current intensity and the magnetic field created. These thermal and electrodynamic stresses are very hazardous for the contacts of the switch (4), being able to cause irreparable damage to the mentioned contacts if they are not quickly removed.

[0007] It is very important for the contacts of the switch to be in the best possible conditions in order to cut off the current in the event of a fault as well as to prevent unwanted phenomena, such as the deterioration or the possibility of the contacts of the switch being welded together due to a pre-arc formed during the closing of the switch, for example.

[0008] It is possible in the opening that the vacuum switch will extinguish the arc before the current reaches a zero. This phenomenon, referred to as chop current, occurs on occasions where the vacuum switch cuts off small currents, such as, for example, active currents or field currents, and it is accompanied by a voltage surge. The immediate zero-crossing of the current induces a transient recovery voltage in the line, which is dependent on the value of the chop current. The greater the value of the chop current the greater the peak of the induced transient voltage, so the risk of re-ignition of the arc is greater and the insulation of the equipment connected to the grid is more greatly stressed. The induced transient voltage starts to increase in value, but the distance between the contacts of the switch is minimal, so the current will probably be restored. The current will be cut off again at its first zero-crossing but if the distance between contacts is still not sufficient, the arc will be re-ignited again, this sequence being able to be repeated several times to the detriment of the installation safety. This situation occurs before the disconnecter has started operating.

[0009] In addition to the re-ignition of the electric arc

due to a high value of the induced transient recovery voltage in breaking-isolation switching, especially in capacitive circuits, the phenomenon of non-sustained disruptive discharges (NSDD), which are discharges produced between the contacts of a vacuum circuit breaker during the industrial frequency recovery voltage period, can also occur, causing a passage of high frequency current linked to the stray capacitance in the area nearby the switch. This phenomenon is more probable in vacuum circuit breakers.

[0010] When the re-ignition of the arc occurs after a break in a capacitive circuit, the voltage increases on the load side, and therefore the voltage supported between the open contacts of the vacuum switch must be greater, which increases the probability of a new re-ignition of the electric arc occurring.

[0011] On the other hand, the growing trend to use vacuum technology is reinforced and assured by the appearance of the distributed generation (solar energy, wind energy, etc.), which has aided in the development of the concept of micro-grids and Smart Grids. These grids act like smart systems capable of having a two-way relationship with the electric power system, i.e., if needed, they absorb energy but they can also inject it, so the number of breaking and connection switching operations in the distribution step increases exponentially. Furthermore, breaking devices must assure that in response to a power system failure which causes the disconnection thereof, the micro-grid is disconnected from the load for two reasons: to prevent the disruption of the electric system from affecting the loads supplied by the micro-grid and to prevent the so-called islanding effect, whereby loads of grids other than the micro-grid are supplied solely by the sources present in the micro-grid. Therefore, for safe operation of these new electric power generation and distribution solutions, highly reliable and very durable breaking elements are essential. A possible cause of islanding is the failure in the opening of the switches which control the power flow (absorption/injection) of micro-grids when a failure occurs in the electric system forcing the disconnection thereof. It is therefore very important to assure the cutoff, but not only of high fault currents but also of small currents, especially capacitive currents.

[0012] The controlgear is usually insulated in a dielectric medium, which is normally air or another fluid medium, such as, for example, sulfur hexafluoride (SF_6), dry air, oil, etc., for the purpose of reducing the distance between phases and thereby achieving a compact enclosure that is impermeable to outside or environmental conditions such as contamination or moisture. In this sense, the enclosure may or may not be leak-tight, depending on the dielectric medium used.

Description of the Invention

[0013] The present invention relates to electrical switchgear that can be applied in electric power distribution installations, such as, for example, electric trans-

former sub-stations, distribution centers, sub-stations, etc., for electric circuit protection and switching. Said switchgear comprises an enclosure, this enclosure being able to be leak-tight and therefore insulated in a fluid, such as, for example, sulfur hexafluoride (SF_6), dry air, oil, etc.

[0014] The switchgear of the invention comprises:

- switching means arranged between at least one bar of a main circuit and at least one shunting bar, said switching means comprising at least one circuit breaker and a switch-disconnector connected in series (these switching means can be housed inside the enclosure). Switch-disconnector is understood as a disconnector with load opening (breaking) capacity of the electric circuit
- at least one switching mechanism for operating the switching means, such that they can perform breaking and/or connection and/or isolation and/or earthing functions (the switching mechanism can be arranged outside the enclosure)
- intensity and/or voltage measuring means and at least one control/protection device for activating the operation of the at least one switching mechanism.

[0015] According to the invention the operation of the switching means depends on the reading of the measuring means, such that a first switching mechanism operates the opening of the switch-disconnector in the case of currents equal to or less than the nominal current, whereas a second switching mechanism operates the opening of the circuit breaker before the opening of the switch-disconnector in the case of currents greater than the nominal current.

[0016] The measuring means measure the intensity and/or voltage magnitudes, and depending on the reading obtained, at least one control/protection device, such as, for example, a relay, commands the operation of the circuit breaker or the switch-disconnector. Therefore, the detection of a current equal to or less than the nominal current, such as, for example, a capacitive or inductive current, entails the opening of the switch-disconnector instead of the opening of the circuit breaker. The switch-disconnector can be a hinge-type three-position earthing switch-disconnector (connection-isolation-earthing) and is integrated inside the enclosure which can be leak-tight and insulated in a fluid, such as, for example, SF_6 . On the other hand, the circuit breaker comprises a vacuum bottle and is also integrated inside the enclosure.

[0017] The fact that the operation of the switching means depends on the readings of the measuring means and that the small currents ($\leq$ nominal currents) are cut off in an extinguishing and insulating medium with a high dielectric strength, for example SF_6 , allows preventing transient recovery voltage peaks and re-ignition situations, as well as reducing stress on the insulations of the equipment electric. As a result of these features in breaking-isolation switching, the phenomenon of non-sus-

tained disruptive discharges (NSDD) is also prevented. Likewise, given that the opening (breaking) switching operations are distributed between the circuit breaker and the switch-disconnector, the number of switching operations that the vacuum circuit breaker must perform is reduced, so the electrical and mechanical endurance of the assembly formed by the switch-switching mechanism is greater.

[0018] The possibility that the switch-disconnector can be switching means with short-circuit making capacity has been contemplated. The second switching mechanism therefore operates the closing of the circuit breaker before the closing of the switch-disconnector in a connecting operation, and accordingly, the circuit breaker does not sustain any wear due to the pre-arc of the closure, the circuit breaker therefore being maintained in the best possible conditions for being able to cut off currents greater than the nominal current, and to therefore prevent unwanted phenomena, such as the deterioration or the possibility of the contacts of the switch being welded together, for example.

[0019] According to a first embodiment, the circuit breaker is connected to the shunting bar and in series with the circuit breaker, and the switch-disconnector is installed upstream in connection with the bar of the main circuit. In this sense, the first and second switching mechanisms comprise a mechanical interlocking such that the circuit breaker and the switch-disconnector can be operated one after the other according to the opening or connecting sequence explained above.

[0020] According to a second embodiment, the circuit breaker is connected to the bar of the main circuit and in series with the latter, and the switch-disconnector is installed downstream, said switch-disconnector being connected to the shunting bar. In this embodiment it is not necessary to arrange any mechanical interlocking.

[0021] Furthermore, the possibility that the operation of the circuit breaker and of the switch-disconnector is motor-driven has been contemplated.

[0022] Finally, there are highly reliable and very durable switching elements even for a safe operation of new electric generation and distribution solutions, such as of micro-grids and of "Smart Grids", assuring that in response to a failure in the power system that causes the disconnection thereof, the micro-grid is disconnected from the load, thereby preventing the so-called islanding effect and preventing the disruption of the electric system from affecting the loads supplied by the micro-grid.

Description of the Drawings

[0023] To complement the description and for the purpose of aiding to better understand the features of the invention according to a preferred practical embodiment thereof, a set of drawings is attached as an integral part of said description in which the following has been depicted with an illustrative and nonlimiting character:

Figure 1 shows a single-line diagram relating to the state of the art of electrical switchgear comprising a disconnector (10) and a circuit breaker (4).

Figure 2 shows a single-line diagram of the electrical switchgear according to a first embodiment of the invention, showing the earthing switch-disconnector (5) connected in series upstream of the circuit breaker (4), both switching means being integrated inside the enclosure (1).

Figure 3 shows a single-line diagram of the electrical switchgear according to a second embodiment of the invention, showing the earthing switch-disconnector (5) connected in series downstream of the circuit breaker (4), both switching means being integrated inside the enclosure (1).

[0024] Figure 4 shows a perspective view of the enclosure (1) with the switching mechanisms (8, 9) on the outside according to the embodiment of Figure 2.

Preferred Embodiment of the Invention

[0025] As shown in Figure 2, the invention relates to electrical switchgear integrated inside an enclosure (1) comprising a series of elements, among others, switching means (4, 5) which allow performing breaking and/or connection and/or isolation and/or earthing switching functions of the electric circuit. The enclosure is leak-tight, and therefore insulated in a fluid, such as, for example, sulfur hexafluoride (SF₆), dry air, oil, etc.

[0026] The switching means comprise a two-position (breaking-connection) circuit breaker (4) and a three-position (connection-isolation-earthing) earthing switch-disconnector (5) which can be a hinge-type switch-disconnector. The circuit breaker (4) is a vacuum switch installed inside the enclosure (1), said switch (4) being connected to the shunting bar (3). The switch-disconnector (5) is installed in series with the switch (4) and upstream in connection with the bar of the main circuit (2), being integrated inside the enclosure (1), and therefore insulated in the insulating fluid contained in said enclosure.

[0027] According to Figure 3, the possibility that the switch-disconnector (5) is connected in series and downstream of the switch (4) has been contemplated, such that the circuit breaker (4) is connected to the bar of the main circuit (2) and the switch-disconnector (5) is connected to the shunting bar (3).

[0028] The circuit breaker (4) comprises a switching mechanism (9) and the switch-disconnector (5) comprises another switching mechanism (8), these switching mechanisms (8, 9) being responsible for producing and transmitting the operating force to said switching means (4, 5) for performing breaking and/or connection and/or isolation and/or earthing functions. As shown in Figure 4, these switching mechanisms (8, 9) are installed outside the enclosure (1).

[0029] The operation of the switching means (4, 5) can

be manual or the operation of the circuit breaker (4) and of the switch-disconnector (5) can be motor-driven as shown in the embodiment of Figure 2.

[0030] The electrical switchgear also comprises intensity measuring means (6) and/or voltage measuring means (7) which can be installed both upstream of the switch-disconnector (5), for example in the case of providing voltage/intensity detection in bars of the main circuit (2), or they can be installed downstream of the circuit breaker (4) as shown in the embodiment of Figure 2,.

[0031] The measurement of the intensity and/or voltage magnitudes obtained through the measuring means (6, 7) is treated by at least one control/protection device, for example a relay, and the control/protection device commands the operation of the switch (4) or of the switch-disconnector (5) depending on the value of said magnitudes. In this sense, the measurement of a current equal to or less than the nominal current, such as, for example, a capacitive or inductive current, entails the opening (breaking) of the switch-disconnector (5) instead of the opening of the circuit breaker (4). In contrast, in the case of currents greater than the nominal current, the switching mechanism (9) operates the opening (breaking) of the circuit breaker (4) before the opening of the switch-disconnector (5).

[0032] Small currents ($\leq$ nominal current) are cut off in an extinguishing and insulating medium with a high dielectric strength, such as, for example, SF₆, whereas high currents ($>$ nominal current) are cut off by means of a highly reliable and very durable breaking element based on vacuum technology.

[0033] The switch-disconnector (5) is switching means with short-circuit making capacity. The switching mechanism (9) therefore operates the closing of the circuit breaker (4) before the closing of the switch-disconnector (5) in a connecting operation, and accordingly, the circuit breaker (4) does not sustain any wear due to the pre-arc of the closure.

[0034] The switching mechanisms (8, 9) comprise a mechanical interlocking such that the circuit breaker (4) and the switch-disconnector (5) can be operated one after the other according to the opening or connecting sequence.

[0035] The reference numbers used in this text represent the following elements:

- 1.- Enclosure
- 2.- Bar of a main circuit
- 3.- Shunting bar
- 4.- Circuit breaker
- 5.- Earthing switch-disconnector
- 6.- Intensity measuring means
- 7.- Voltage measuring means
- 8.- Switching mechanism of the switch-disconnector (5)
- 9.- Switching mechanism of the circuit breaker (4)
- 10.- Earthing disconnector

[0036] On the other hand, the invention is not limited to the specific embodiments described, but also covers, for example, the variants that can be devised by the person skilled in the art (for example, those variants in terms of the choice of the materials, size, components, configuration, etc.), within that which is inferred from the claims.

Claims

1. High-voltage electrical switchgear comprising:

an enclosure (1),
switching means arranged between at least one bar of a main circuit (2) and at least one shunting bar (3), said switching means comprising at least one circuit breaker (4) and a switch-disconnector (5) connected in series,
at least one switching mechanism (8, 9) for operating the switching means (4, 5), such that they can perform breaking and/or connection and/or isolation and/or earthing functions and intensity and/or voltage measuring means (6, 7), as well as at least one control/protection device for activating the operation of the at least one switching mechanism (8, 9),

characterized in that the operation of the switching means (4, 5) depends on the reading of the measuring means (6, 7), such that at least one switching mechanism (8, 9) operates the opening of the switch-disconnector (5) instead of the opening of the circuit breaker (4) in the case of currents equal to or less than the nominal current, whereas it operates the opening of the circuit breaker (4) before the opening of the switch-disconnector (5) in the case of currents greater than the nominal current.

2. Electrical switchgear according to claim 1, **characterized in that** the switch-disconnector (5) is switching means with short-circuit making capacity.

3. Electrical switchgear according to claim 2, **characterized in that** the switching mechanism (9) operates the closing of the circuit breaker (4) before the closing of the switch-disconnector (5) in a connecting operation.

4. Electrical switchgear according to claim 3, **characterized in that** the switching mechanisms (8, 9) comprise a mechanical interlocking such that the circuit breaker (4) and the switch-disconnector (5) can be operated one after the other according to the opening or connecting sequence.

5. Electrical switchgear according to claim 4, **characterized in that** the operation of the circuit breaker (4) and of the switch-disconnector (5) is motor-driven.

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6. Electrical switchgear according to any of the preceding claims, **characterized in that** the circuit breaker (4) comprises a vacuum bottle. 5
 7. Electrical switchgear according to any of the preceding claims, **characterized in that** the switching means (5) are a three-position earthing switch-disconnector. 10
 8. Electrical switchgear according to claim 7, **characterized in that** the switch-disconnector (5) is a hinge-type switch-disconnector. 15
 9. Electrical switchgear according to any of the preceding claims, **characterized in that** the enclosure (1) is leak-tight and incorporates a dielectric fluid. 20
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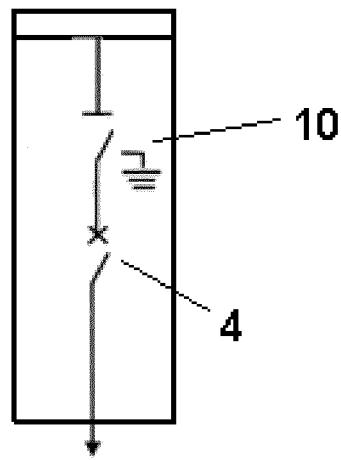


Fig. 1

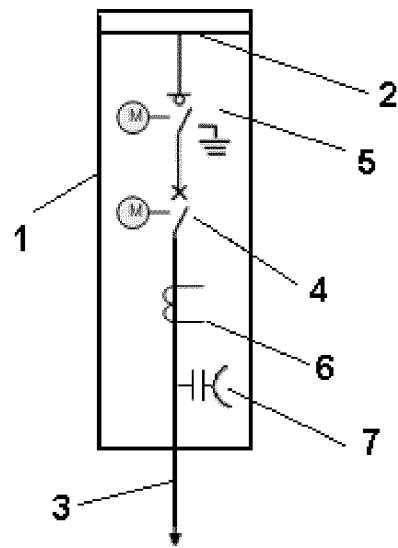


Fig. 2

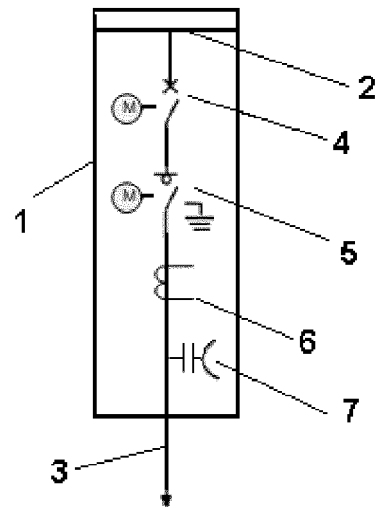


Fig. 3

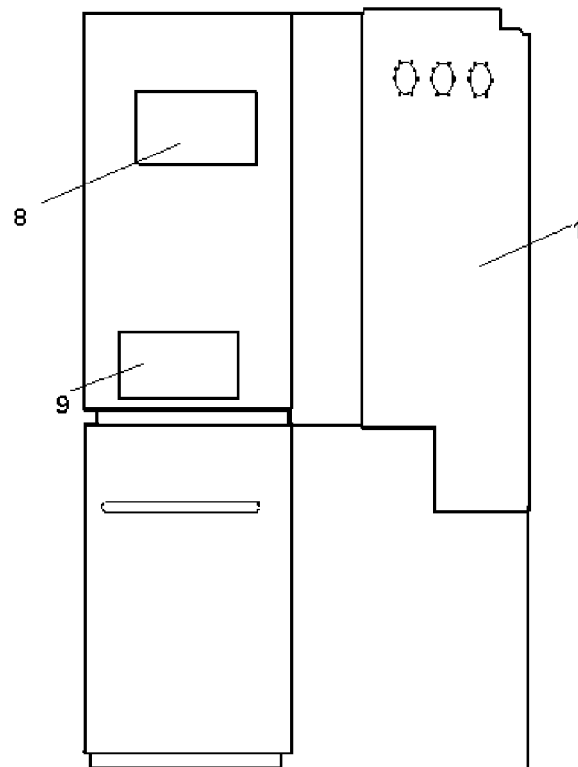


Fig. 4



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Application Number
EP 13 38 2026

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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