

MODULAR ASSEMBLY MULTIPOLE EARTH LEAKAGE CIRCUIT BREAKER

The invention relates to a multipole electrical circuit breaker with earth leakage protection formed by modular side-by-side assembly of a circuit breaker unit and an earth leakage trip unit, said circuit breaker unit having a first pair of opposite side faces, and housing a multipole breaking device with separable contacts actuated by an operating mechanism operated by a handle and a trip device sensitive to overload and short-circuit currents, said earth leakage trip unit sensitive to an earth leakage current having a case with a second pair of opposite side faces, and housing :

- a tripping relay,
- a first mechanical link capable of transmitting a tripping order from the relay to the operating mechanism when an earth leakage fault occurs,
- a second mechanical link to derive from the opening movement of the handle an automatic resetting movement of the relay,
- a test circuit having at least one test resistor in a leakage branch circuit,
- a test button closing of which creates an artificial earth leakage current,
- a protective switch designed to disconnect the test resistor and to interrupt the artificial earth leakage current in the test circuit, after opening of the circuit breaker by earth leakage tripping,
- one of the faces of the second pair of the trip unit case coming into engagement with the circuit breaker unit comprising openings for transverse passage of the first and second mechanical links.

The earth leakage trip unit of a miniature circuit breaker generally houses the earth leakage current detector formed by a transformer in the form of a toroid surrounding the active

conductors of the power system to be protected. In the electro-mechanical version of the earth leakage trip device described in the document FR-A-2,437, 692, the secondary winding is connected directly to the tripping relay, and it is then indispensable to provide a trip unit for each tripping sensitivity.

In the electronic version of the earth leakage trip device, an electronic circuit is fitted between the secondary winding and the relay to obtain a high-sensitivity earth leakage protection device. A special earth leakage trip unit is also necessary. The number of different trip units gives rise to problems of storage and cost price for a range of miniature circuit breakers.

The document DE-A-1,256,775 describes a four-pole earth leakage circuit breaker, the inside of whose case is divided into three compartments, i.e. a first compartment housing the poles with their arc extinguishing chambers, a second compartment comprising the circuit breaker operating mechanism, the two trip devices for overload and short-circuit, and the earth leakage transformer for earth leakage current detection, and a third compartment for housing the earth leakage tripping relay, and test circuit. The earth leakage transformer is housed in the same compartment as the operating mechanism and the overload and short-circuit trip devices. Such an arrangement does not enable the second compartment to be separated physically from the first compartment.

The object of the invention consists in achieving a modular earth leakage circuit breaker using the maximum of common parts for each of the electromechanical or electronic versions.

The circuit breaker according to the invention is characterized in that the other face of the second pair of the trip unit case acts alternately as support :

- either in the electromechanical version for a detector unit containing a summing transformer for detection of a residual earth leakage current, said detector unit then being adjoined to the earth leakage trip unit,

- or in the electronic version for an auxiliary unit containing an electronic circuit controlled by tripping and power supply signals from the detector unit, said auxiliary unit then being adjoined to the earth leakage trip unit, and the detector unit being separate from the trip unit.

The earth leakage trip unit is connected by an internal electrical connection either to the measurement winding of the transformer incorporated in the detector unit for the electromechanical version or to the electronic circuit board of the auxiliary unit for the electronic version. It can be noted that the structures of the circuit breaker unit, trip unit and detector unit are identical for each version, the only modification being the presence or absence of the auxiliary unit with suitable wiring.

The front panel of the auxiliary unit is equipped with a selector for adjusting the earth leakage tripping sensitivity setting, and with a time delay button for adjusting the earth leakage tripping delay setting. The trip unit comprises a built-in remote opening control by artificial earth leakage tripping, and an earth leakage tripping visualization window, located near the test button.

The detector unit is electrically connected by a flat connecting strap to a connector of the electronic circuit of the auxiliary unit in such a way as to transmit the power supply and the earth leakage current measuring signal to the electronic circuit board, and to perform connection of the test circuit with the power supply system line-side and load-side of the transformer.

According to a development of the invention, the electronic circuit comprises load resistors of the transformer secondary winding, cooperating with the setting selector to select the earth leakage tripping sensitivity, said selector being in connection with an auxiliary switch designed to be actuated by the test button to impose automatic switching of the selector to the highest sensitivity when the test circuit is closed.

Other advantages and features will become more clearly apparent from the following description of an illustrative embodiment of the invention, given as a non-restrictive example only and represented in the accompanying drawings, in which :

Figure 1 represents the schematic electrical wiring diagram of a circuit breaker with an electromechanical earth leakage trip device ;

Figure 2 is an elevational view of the earth leakage trip unit designed to be associated with the breaking unit of the circuit breaker, represented in the closed-set position ;

Figures 3 to 5 respectively show cross-sectional views of the earth leakage trip unit along the lines III-III, IV-IV, and V-V of figure 2 ;

Figure 6 shows a schematic view of modular assembly of the circuit breaker according to figure 1, comprising a breaking unit, an earth leakage trip unit, and a detector unit with summing transformer ;

Figure 7 is a plan view of figure 6, with the detector unit cover removed ;

Figure 8 is the electrical wiring diagram of an alternative embodiment with a circuit breaker equipped with an electronic

earth leakage trip device ;

Figure 9 represents the diagram of the electronic circuit of the auxiliary unit ;

Figure 10 shows the schematic view of modular assembly of the earth leakage circuit breaker according to figure 8.

Figure 1 shows the electrical wiring diagram of a two-pole differential circuit breaker connected in a single-phase A.C. power system having a phase conductor L and neutral conductor N. The differential circuit breaker 10 comprises a two-pole or single-pole plus neutral breaking device with separable contacts 14, 16 actuated by an operating mechanism 18 with a handle 19, which cooperates with a magnetic and thermal trip device (not represented) sensitive to overload and short-circuit currents, and an earth leakage trip device 20 sensitive to an earth leakage current.

The earth leakage trip device 20 comprises a residual earth leakage current detector formed by a summing transformer 21 for detection of a ground fault current, having a toroidal core 22 surrounding the active conductors L and N, and a measurement winding 24 wound onto the core 22. The measurement winding 24 is electrically connected to a polarized electromagnetic tripping relay 26 cooperating with the mechanism 18 via a first mechanical tripping link 27 so as to bring about automatic opening of the contacts 14, 16, when an earth leakage fault occurs in the conductors L and N. A test circuit 28 is associated with the earth leakage trip device 20 and is electrically connected by a conductor 29 to a first connection point 30 of the phase conductor L, and by a conductor 31 to a second connection point 32 of the neutral conductor N, respectively line-side and load-side of the summing transformer 21. The test circuit 28 constitutes a branched leakage circuit

comprising a pair of test resistors 34, 36, an interruption or protection device 38 with double protection contacts 40, 42, and a test button 44 of the pushbutton type. Manual closing of the test button 44 simulates an earth leakage current by connecting the resistors 34, 36 in the test circuit 28, enabling correct operation of the earth leakage trip device 20 to be checked. The artificial earth leakage current flows in the test circuit 28 from the first connection point 30 of the phase conductor L via the resistor 36, protection contact 40, test button 44, protection contact 42, and resistor 34, and returns to the second connection point 32 of the neutral conductor N.

In the earth leakage tripping phase controlled by the relay 26, opening of the protection contacts 40, 42 of the interruption device 38 takes place automatically due to a second mechanical link 45 of the mechanism 18, causing the two resistors 34, 36 to be disconnected from the circuit, even in case of continued depression of the test button 44. The interruption device 38 of the test circuit 28 is located between the test button 44 and the resistors 34, 36.

A remote tripping control can be associated with the mechanism 18 of the circuit breaker 10, and comprises a simple remote-control contact 46 connected in a connecting circuit 48 designed to be electrically connected in parallel to the terminals 50, 52 of the test button 44. Actuation of the remote-control contact 46 results in the same effect as local closing of the test button 44, i.e. opening of the contacts 14, 16 of the circuit breaker 10 by earth leakage tripping.

The presence in the test circuit 28 of the two protection contacts 40, 42 of the interruption device 38 enables the test button 44 and remote-control contact 46 to be fully isolated from the power system after earth leakage tripping. Powering-off by total disconnection of the two buttons 44, 46 is achieved by

simultaneous interruption of the two conductors 29, 31, regardless of the connection mode of the circuit breaker 10, i.e. in the case of line-side power supply (terminals 51, 53) or in the case of opposite load-side power supply (terminals 54, 56).

The presence of a test resistor 34, 36 in each conductor 31, 29 of the test circuit 28 enables total safety to be achieved for the user, even in case of accidental welding of one of the protection contacts 40, 42.

Referring to figures 2 to 5, the mechanism 60 of the earth leakage trip unit 20 is housed in an insulating case 62 designed to be juxtaposed and coupled to the circuit breaker unit 11 housing the breaking device 12, mechanism 18 and magnetic and thermal trip device. The tripping relay 26 of the mechanism 60 comprises a movable blade (not represented) designed to cooperate with an actuating arm 63 of a drive lever 64 pivotally mounted on a spindle 66 between a set position and a tripped position. The drive lever 64 bears a finger 68 forming the first mechanical tripping link 27 designed to release the lock of the mechanism 18 of the circuit breaker 10 when the blade of the relay 26 is actuated to the tripped position following an earth leakage fault.

The second mechanical link 45 of the earth leakage mechanism 60 connects the handle 19 of the mechanism 18 of the circuit breaker 10 to a transmission cam 70 pivotally mounted on a spindle 72 in such a way as to follow the opening and closing movements of the handle 19. The transmission cam 70 cooperates on the one hand with an arm 74 of a resetting lever 76 and on the other hand with an indicating lever 78, both pivotally mounted on the same spindle 80.

A lock 82 (figs. 2 and 4) is pivotally mounted on a spindle 84

and comprises a retaining nose designed to lock the indicating lever 78 in an inactive position in which a flag 88 is removed from a visualization window 90 arranged in the front panel of the case 62.

Operation of the earth leakage mechanism 60 is as described in French Patent n° 2,437,692 which should be referred to for further details.

On the insulating spindle of the levers 76, 78, there is wound a torsion type spring 92, made of metallic electrical conducting material. One of the ends 94 of the spring 92 bears on an edge of the resetting lever 76 in such a way as to bias it clockwise, bearing on the cam 70. The end 94 of the spring can in addition cooperate with a first fixed conducting tab 96 to constitute the protection contact 40 of the interruption device 38 of the test circuit 28. The other end 97 of the spring 92 is in engagement against a stop 98 of the case 62, and is connected to the resistor 36 electrically connected by the conductor 29 to the first connection point 30 of the phase conductor L.

The other protection contact 42 of the interruption device 38 comprises a second fixed conducting tab 100 designed to cooperate with a flexible contact part 102. The opposite end of this blade 102 is securely united to a fixed anchoring 104 of the case 62 surrounding the pivoting spindle 66 of the drive lever 64, and is electrically connected to the resistor 34 connected in the conductor 31 of the test circuit 28. The contact blade 102 is actuated by a finger 103 of the resetting lever 76.

The two fixed tabs 96, 100 are connected respectively to two connectors 106, 108 of the connection circuit 48 of the remote-control contact 46, the two connectors 106, 108 being in electrical connection with the terminals 50, 52 of the test

button 44. A plug 110 can blank off the opening giving access to the connectors 106, 108 when the remote tripping control is not connected to the earth leakage trip device 20.

The test button 44 is equipped with a deformable flexible blade 112 described in detail in French Patent n° 2,526,995. The blade 112 comes into contact in the depressed position of the test button 44 with the first fixed tab 96 of the protection contact 40.

Operation of the mechanism 60 of the earth leakage trip device 20 according to figures 2 to 5 is as follows :

When the circuit breaker 10 is closed corresponding to the position in figure 2 of the mechanism 60 of the earth leakage trip device 20, the occurrence of an earth leakage fault causes tripping of the relay 26 resulting in clockwise pivoting of the drive lever 64 around the spindle 66, from the set position to the tripped position. The finger 68 of the first mechanical link 27 transmits the tripping order to the lock of the mechanism 18 of the circuit breaker 10 which opens the contacts 14, 16 of the breaking device 12 and releases the lock 82 of the indicating lever 78. Opening of the circuit breaker 10 is accompanied by a counterclockwise pivoting movement of the handle 19 and transmission cam 70. The second mechanical link 45 with the mechanism 18 derives from the opening movement of the circuit breaker an automatic resetting movement of the relay 26 by means of the drive lever 64 urged by the resetting lever 76. The indicating lever 78 in addition moves the flag to an active position facing the visualization window 90 to indicate tripping on an earth leakage fault. After resetting of the relay 26, the second mechanical link 45 moves the resetting lever 76 and indicating lever 78 back to their original position when the handle 19 is moved manually from the open position to the closed position of the circuit breaker.

Simulation of an earth leakage fault is achieved by depressing the test button 44 resulting in the resistors 34, 36 being connected in the test circuit 28. The flexible contact blade 112 comes into contact with the terminal 50 of the first tab 96. After the circuit breaker 10 has opened, the two protection contacts 40, 42 open automatically by the clockwise pivoting movement of the resetting lever 76. The end 94 of the spring 92 and the contact blade 102 move respectively away from the first and second fixed tabs 96, 100, and perform disconnection of the two resistors 34, 36. The test circuit 28 is thus kept fleetingly powered on during the response time of the circuit breaker mechanism 18. The terminals 50, 52 and connectors 106, 108 are powered off when the circuit breaker is open.

When the handle 19 of the circuit breaker 10 is then actuated to the closed position after resetting of the relay 26 of the earth leakage trip device 10, the resetting lever 76 urges the protection contacts 40, 42 to the closed position. A new test can then be performed.

It can be noted that the actuating arm 63 of the lever 64 is common to the first and second mechanical links 27, 45, and acts both as tripping component, when a tripping signal is sent to the coil of the relay 26, and as resetting component of the relay 26, when the circuit breaker opens. The arm 63 has associated with it a flexible tab 120 (fig.2) made of insulating material, designed to maintain a preset clearance 122 between the arm 63 and the blade after the relay 26 has been reset, and when the handle 19 of the circuit breaker 10 is moved from the open position to the closed position. The presence of this clearance enables a good transmission of the tripping order coming from the relay 26.

Figures 6 and 7 show the modular assembly of the earth leakage trip device 10 according to figure 1, with the electromechanical

earth leakage trip unit 20 fitted between the two-pole circuit breaker unit 11 and the detector unit 150 with summing transformer 21 for detection of the residual earth leakage current. The secondary winding 24 of the transformer 21 incorporated in the detector unit 150 is connected to the coil of the relay 26 of the earth leakage trip unit 20 by an internal electrical connection 152. Each pole of the circuit breaker unit 11 is for example of the type described in French Patent application n° 86 00111 filed on 03.01.86 by the applicant, but any other miniature multipole circuit breaker can be used. The handle 19 is mechanically coupled to the second mechanical link 45 of the earth leakage trip unit 20, whereas the first mechanical tripping link 27 controls the lock of the mechanism 18.

The earth leakage circuit breaker 10 comprises a pair of intermediate connecting conductors 154, 156 connected between the lower terminals 158, 160 of the two-pole circuit breaker unit 11 and the upper terminals 162, 164 of the detector unit 150. The power supply to the earth leakage circuit breaker 10 is system-powered, and the power system conductors L, N are connected to the line-side terminals 51, 53 of the circuit breaker unit 11, and to the load-side terminals 54, 56 of the detector unit 150. The toroid 22 of the summing transformer 21 comprises two primary windings 166, 168 whose opposite ends are connected to the corresponding upper terminals 162, 164 and load-side terminals 54, 56 of the detector unit 150. Input of the intermediate conductors 154, 156 to the detector unit 150 is performed via openings 170, 172 arranged under the load-side terminals 54, 56.

Figures 8 to 10 concern an alternative embodiment of an electronic earth leakage circuit breaker 200 with auxiliary power supply source. The same reference numbers will be used to designate identical or similar parts to those of the circuit

breaker 10 in figures 1 to 7. The earth leakage circuit breaker 200 comprises a modular assembly of a two-pole circuit breaker unit 11 adjoined to the earth leakage trip unit 20, and to an auxiliary unit 202 housing an electronic processing circuit 204 of the signals coming from the separate detector unit 150.

A flat strap 206 of five connecting wires connects the detector unit 150 to an input connector 208 of the electronic circuit 204 to perform on the one hand transmission of a measuring signal from the secondary winding 24, and of a second signal for the power supply source Vcc, and on the other hand connection of the test circuit 28 of the earth leakage trip unit 20 to a push-button 44.

The electronic circuit 204 of the auxiliary unit 202 is connected to the relay 26, test circuit 28, test button 44 and remote-control button 46 of the trip unit 20 by an eight-wire internal connection 210.

The front panel of the auxiliary electronic unit 202 is provided with a selector 212 for adjustment of the earth leakage tripping sensitivity setting (for example 30 mA, 300 mA, 1 A, 3 A), and with a time delay button 214 for adjustment of the earth leakage tripping time delay setting.

The electronic circuit 204 (fig. 9) of the auxiliary unit 202 comprises a network of sensitivity adjusting resistors R0, R1, R2, R3, and the secondary winding 24 of the summing transformer 21 is loaded by one or more of these resistors R0 to R3 according to the position of the selector 212. The highest sensitivity of 30 mA corresponds to connection of the resistor R0, whereas the 300 mA, 1A and 3A sensitivities correspond to parallel connection of R1, R2, R3 with the resistor R0. The output of the resistor network R0 to R3 is connected to an operational amplifier 216, arranged as a comparator which

controls an earth leakage tripping signal processing circuit 218. The remote-control contact 46 is connected directly to the processing circuit 218 by resistors 220, 222. The output of the processing circuit 218 is connected to one of the inputs of a logic OR gate 224 which controls excitation of the coil of the tripping relay 26.

The output terminal 226 of the secondary winding 24 of the transformer 21 is connected by a resistor 228 to the power supply source Vcc, and by a capacitor 230 to the resistor network R0 to R3. The other input of the logic OR gate 224 is connected by a conductor 232 to the terminal 226 of the winding 24. A bad continuity of the secondary circuit of the detector unit 150 causes a potential increase of the terminal 226, delayed by the time constant RC of the resistor 228 and capacitor 230. The logic OR gate 224 can thus receive two tripping orders comprising a first tripping signal on an earth leakage fault generated by the processing circuit 218, and a second tripping signal on a secondary circuit continuity fault. Discrimination between the two tripping signals is made by the opening time delays of the earth leakage circuit breaker 200.

The sensitivity setting selector 212 is grounded by means of an auxiliary switch 232 (figs. 8 and 9), which is housed in the trip unit 20 and is actuated when the test button 44 is depressed (see figs. 2 and 5), causing with closing of the test circuit 28 an automatic interruption of the grounding connection of the selector 212. This results in forced switching to the highest sensitivity, i.e. 30 mA (resistor R0), regardless of the position of the selector 212. In operation without test of the circuit breaker 200, a degradation of the selector 212 or auxiliary switch 232 leads to an increased sensitivity of the electronic circuit 204.

In the electromechanical version of the earth leakage circuit

breaker 10 in figure 7, the detector unit 150 forms part of the modular assembly being compulsorily adjoined to the trip unit 20. In the electronic version of the earth leakage circuit breaker 200 in figure 10, the auxiliary unit 202 of the electronic circuit 204 is arranged side-by-side with the trip unit 20, whereas the detector unit 150 is physically separated from the modular assembly, with simple electrical connections with the circuit breaker unit 11 (conductors 154, 156) and electronic circuit 204 (flat connecting strap 206).

CLAIMS

1. A multipole electrical circuit breaker with earth leakage protection formed by modular side-by-side assembly of a circuit breaker unit (11) and an earth leakage trip unit (20), said circuit breaker unit (11) having a first pair of opposite side faces, and housing a multipole breaking device (12) with separable contacts (14, 16) actuated by an operating mechanism (18) operated by a handle (19) and a trip device sensitive to overload and short-circuit currents, said earth leakage trip unit sensitive to an earth leakage current having a case (62) with a second pair of opposite side faces, and housing :

- a tripping relay (26),
- a first mechanical link (27) capable of transmitting a tripping order from the relay (26) to the operating mechanism (18) when an earth leakage fault occurs,
- a second mechanical link (45) to derive from the opening movement of the handle (19) an automatic resetting movement of the relay (26),
- a test circuit (28) having at least one test resistor (34, 36) in a leakage branch circuit,
- a test button (44) closing of which creates an artificial earth leakage current,
- a protective switch (38) designed to disconnect the test resistor and to interrupt the artificial earth leakage current in the test circuit (28), after opening of the circuit breaker (10, 200) by earth leakage tripping,
- one of the faces of the second pair of the case (62) of the trip unit (20) coming into engagement with the circuit breaker unit (11) comprising openings for the transverse passage of the first and second mechanical links (27, 45), characterized in that :

the other face of the second pair of the case (62) of the trip



unit (20) acts alternately as support :

- either in the electromechanical version for a detector unit (150) containing a summing transformer (21) for detection of a residual earth leakage current, said detector unit (150) then being adjoined to the earth leakage trip unit (20),

- or in the electronic version for an auxiliary unit (202) containing an electronic circuit (204) controlled by tripping and power supply signals from a detector unit (150), said auxiliary unit (202) then being adjoined to the earth leakage trip unit (20), and the detector unit (150) being separate from the trip unit (20).

2. The electrical circuit breaker according to claim 1, characterized in that the earth leakage trip unit (20) is connected by an internal electrical connection (152, 210) either to the measurement winding (24) of the transformer (21) incorporated in the detector unit (150) for the electromechanical version or to the board of the electronic circuit (204) of the auxiliary unit (202) for the electronic version.

3. The electrical circuit breaker according to claim 2, characterized in that the front face of the auxiliary unit (202) is equipped with a selector (212) for adjustment of the earth leakage tripping sensitivity setting, and with a time delay button (214) for setting of the earth leakage tripping delay, and that the trip unit (20) comprises a built-in remote opening mechanism by artificial earth leakage tripping, and a window (90) for visualization of earth leakage tripping, located in proximity to the test button (44).

4. The electrical circuit breaker according to one of the claims 1 to 3, characterized in that the detector unit (150) is electrically connected by a flat connecting strap (206) to a



connector (208) of the electronic circuit (204) of the auxiliary unit (202) in such a way as to transmit the power supply and the earth leakage current measurement signal to the board of the electronic circuit (204) and to provide connection of the test circuit (28) with the power supply system line-side and load-side of the transformer (21).

5. The electrical circuit breaker according to claim 4, characterized in that the electronic circuit (204) comprises load resistors (R0 to R3) of the secondary winding (24) of the transformer (21), cooperating with the setting adjustment selector (212) to select the earth leakage tripping sensitivity, said selector (212) being in connection with an auxiliary switch (232) designed to be actuated by the test button (44) to impose automatic switching of the selector (212) to the highest sensitivity when the test circuit (28) is closed.

6. The electrical circuit breaker according to claim 5, characterized in that the electronic circuit (204) comprises, in addition :

- a processing circuit (218) of the earth leakage signal, controlled by an operational amplifier comparator (216) connected to the secondary winding (24) by means of the sensitivity adjustment resistors R0 to R3,
- a monitoring circuit (232, 228, 230) of the secondary circuit continuity, arranged between the secondary winding (24) of the summing transformer (21) and the electronic circuit (204),
- and a logic gate (224) capable of taking into account any of the tripping signals on an earth leakage or continuity fault of the secondary circuit, to control the tripping relay (26).

