

TWO-POLE DIFFERENTIAL SWITCH WITH FAULT INDICATOR

The invention relates to a two-pole differential switch with a moulded insulating case housing :

- a pair of separable contacts per pole, comprising a stationary contact and a movable contact in electrical connection with a pair of connection terminals,
- an operating mechanism having a mechanical transmission link arranged between a handle and a device for driving the two movable contacts,
- a spring actuating the mechanism to bring about opening of the contacts when an automatic trip takes place on a fault,
- a differential trip device having a summing transformer for detection of a fault current, and a trip relay designed to cooperate with a main latch of said mechanical link of the mechanism,
- and an automatic resetting device of the relay after tripping, comprising a resetting lever.

A known device of the kind mentioned is described in the documents FR-A-2,530,073 and EP-A-99,786 filed by the applicant. This involves a switch with a differential trip device incorporated in the same casing. Such an apparatus consists in interrupting an electrical circuit, either manually by means of the two-position handle or automatically if an insulation fault occurs exceeding a preset threshold. Opening of the switch poles is indicated by the position of the pivoting handle visible from the front, or by a mechanical indicator securely united to the contacts. This type of indication is unable to distinguish between manual opening or opening on a switch fault.

The document FR-A-2,437,692 filed by the applicant involves a modular differential circuit breaker formed by side-by-side assembly of a circuit breaker unit and a differential trip unit, the latter being equipped with a differential tripping indicator. A sliding rack of the trip unit is controlled by the differential relay, and simultaneously actuates the circuit breaker mechanism trip bar by a first mechanical link, and the indicator lever latch. The relay is reset automatically in the course of opening of the contacts by a second mechanical resetting link formed by coupling of the circuit breaker handle with a cam of the trip unit. The presence of this second mechanical link lengthens the kinematic chain between the relay and the mechanism of the circuit breaker unit, and imposes a certain delay for transmission of the resetting force of the relay and of movement of the differential indicator to the active position.

The document DE-A-1,538,334 relates to a monoblock differential switch having a manual operating mechanism reset button.

The object according to the invention consists in achieving a two-pole differential switch of small dimensions enabling differential tripping to be indicated without any ambiguity.

The switch according to the invention is characterized in that the switch comprises in addition a differential trip indicator lever forming part of a differential fault indicating device, said indicator lever cooperating by latching with an indicator latch controlled by the relay, said indicator lever being capable of occupying either a stable active fault indication position after the indicator latch has been unlatched by the relay, or a stable inactive position after the indicator latch has been relatched by manual movement of the handle to the closed position, that when tripping occurs the relay cooperates with the main latch of the mechanism, and with the indicator

latch of the indicator lever via a common trip bar, that the relay is arranged side-by-side with the operating mechanism in the case, and that after the relay has been reset a protrusion of the device for driving the movable contacts comes into engagement during the closing travel of the handle, with the resetting lever to move it against the return force of a resetting spring to a neutralisation position, enabling another trip to be performed by the differential trip device.

The side-by-side arrangement of the trip relay, differential trip indicator and operating mechanism enables a common trip bar to be used, the opposite ends of which cooperate with a main latch of the mechanism, and an indicator latch of the indicator.

The automatic resetting action of the relay is controlled automatically by the resetting lever return spring when opening takes place, whereas neutralisation of the latter after the relay has been reset takes place in the actual closed position of the movable contacts.

The movable phase and neutral contacts are supported by two insulated support arms securedly united to a pivoting plate constituting the driving device. The protrusion of the plate causes the indicator lever to move from the active position to the inactive position in the course of closing.

According to an embodiment of the invention, the base of the case acts as a housing for the summing transformer and for the system of contacts and connection terminals, whereas the cover houses the operating mechanism, the differential trip device with relay and the differential fault indicator device. The internal volume of the base is subdivided by two longitudinal walls and a transverse wall into a plurality of independent compartments comprising :

- the summing transformer compartment extending over the whole width of the base and arranged between the output terminals and the transverse wall,
- two juxtaposed phase and neutral circuit compartments, located between the input terminals and the transverse wall,
- and a compartment for the test resistor of the test circuit associated with the differential trip device, said compartment being disposed widthwise between the neutral circuit compartment and one of the side faces of the base.

The differential switch is advantageously equipped with a high-speed closing device.

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 is an elevational view of the two-pole differential switch according to the invention, represented in the open position;
- figure 2 is a plan view of the switch according to figure 1, after the cover and operating mechanism with trip relay have been removed;
- figure 3 is a cross-sectional view along the line III-III of figure 1;
- figure 4 is an elevational view of the differential trip device with the indicator and relay in the set position;
- figure 5 shows the wiring diagram of the differential switch.

- figure 6 represents a similar view to figure 1 of an alternative embodiment.

In figures 1 to 4 and 6, the two-pole differential switch 10 is housed in a parallelepipedic case 12, made of moulded insulating material, formed by assembling a base 16 and a cover 14 fixed to one another by two fixing screws 18, 20. The differential switch can be connected to a single-phase plus neutral AC mains system by means of two pairs of connection terminals 22, 24 ; 26, 28, inserted in recesses 30 located at the four opposite corners of the base 16. The input 24 and output terminals 22 form part of a phase circuit 36 connected to the phase conductor L, whereas the input 28 and output terminals 26 belong to a neutral circuit 38 connected to the neutral conductor N. The two input terminals 24 and 28 are arranged side by side along the narrow connection face 34, and the two juxtaposed output terminals 22, 26 extend along the opposite narrow connection face 32.

The base-plate 39 of the base 16 can be mounted by clipping onto a symmetrical DIN rail by means of a fixing device 40. The front face of the cover 14 is provided with an aperture through which a pivoting operating handle 42 passes, and with an orifice housing a test button 44 to check correct operation of the differential trip device 46.

The phase circuit 36 comprises a stationary contact 48 fixed to an extension of the U-shaped conducting terminal pad passing through the tunnel of the input terminal 24, and a movable phase contact 50 borne by an insulating support arm 52 mounted on an articulation spindle 54 securedly united to a pivoting plate 56. The movable phase contact 50 is connected by a braided strip 58 to one of the ends of a primary winding 60 comprising one or more turns wound round the core of a differential or summing transformer 62. The output terminal 22 is connected to the opposite end of the primary winding 60.

The neutral circuit 38 presents a similar structure comprising the input terminal 28 acting as support for a stationary contact 64 capable of cooperating with a movable neutral contact 66 borne by an insulating support arm 68, mounted with the adjacent support arm 52 on the common spindle 54. The movable neutral contact 66 is connected by a braided conducting strip 70 to the second primary winding 72 of the differential transformer 62, and to the output terminal 26.

The differential transformer 62 and the two phase and neutral circuits 36, 38 are housed individually in independent compartments 74, 76, 78, respectively subdivided inside the base 16 by insulating separating walls 80, 82, 84.

The two longitudinal internal walls 80, 82 extend in a parallel direction to the large opposite side faces 86, 88 of the case to confine widthwise, in addition to the two compartments 74, 76 housing the phase and neutral circuits 36, 38, an additional compartment 90 housing the test resistor 92 of the test circuit 94 associated with the differential trip device 46. The compartment 76 housing the neutral circuit 38 is located between the two compartments 74, 90 housing the phase circuit 36 and the resistor 92. The two walls 80, 82 are arranged over a fraction of the length of the base 16 up to the area where they meet the third intermediate transverse wall 84 extending perpendicular to the base-plate 39 up to the separation plane of the base 16 with the cover 14.

The close arrangement of the differential transformer 62 and the phase and neutral circuits 36, 38 between the input terminals 24, 28 and output terminals 22, 26 inside the base 16 enables very short internal electrical connections of the two-pole switch 10 to be achieved. The orifice of the toroid of the differential transformer 62 extends in the longitudinal direction of the poles.

The inside of the cover 14 contains the operating mechanism 96, a trip relay 98 of the differential trip device 46, and a differential fault indicating device 100.

The operating mechanism 96 (figures 1 and 3) is situated between two mounting plates 102, 104, above the compartment 74 housing the phase circuit 36 and the compartment 78 housing the differential transformer 62, and is common to the two movable phase and neutral contacts 50, 66. The articulation spindle 54 of the support arms 52, 68 of the movable contacts 50, 66 is supported by the plate 56 pivotally mounted on a fixed spindle 106 securedly united to one or both of the mounting plates 102, 104. Apertures arranged in the support arms 52, 68 facing the passage of the fixed spindle 106 allow a limited movement of the support arms 52, 68 on the plate 56, a spiral-wound contact pressure spring 108 biasing each arm 52, 68 to the closed position of the contacts 48, 50 ; 64, 66. An opening spring 110 of the operating mechanism 96 is formed by a compression spring inserted between a fixed stop and the plate 56, the latter being urged in rotation on the spindle 106 in the opening direction of the movable contacts in the clockwise rotation direction in figure 1. The plate 56 is equipped with a retaining pin 112 designed to cooperate with the ends of the support arms 52, 68 so as to form a mechanical link with the movable contacts 50, 66. The plate 56 cooperates with a driving and locking device comprising a transmission spindle 114 capable of moving in an aperture 116 arranged in the plate 56. The spindle 114 is formed by the curved end of a connecting rod 118 whose opposite end is articulated on the pivoting manual operating handle 42, in such a way as to form a toggle. A locking catch 120 is mounted with rotation on a fixed spindle 122, and presents on the one hand a retaining surface 124 limiting the movement of the spindle 114 in the aperture 116 in the locked position represented in figure 1, and on the other hand a latching nose 126 operating in conjunction with a latch 128 pivotally mounted on a fixed

spindle 130. A spiral return spring 132 is wound round the spindle 122 and biases the latch 128 and the latching nose 126 to the locked position. The handle 42, mounted with limited pivoting on a spindle 134, is biased to the open position (figure 1) by a spring 136. The latch 128 can be moved against the return force of the spring 132 to a tripped position releasing the latching nose 126, when the relay 98 of the differential trip device 46 operates. The catch 120 then pivots in a clockwise direction in figure 1, and releases the spindle 114 of the connecting rod 118, causing the mechanical link between the toggle-joint 118, 42 and the plate 56 to be broken. This results in automatic opening of the contacts 48, 50 ; 64, 66 by clockwise pivoting of the plate 56 due to the release action of the spring 110 of the mechanism 96. The handle 42 is moved to the open position by its return spring 136. The spring 132 then participates in automatic resetting of the latch 128 and catch 120, so as to re-establish the mechanical link between the toggle 118 and plate 56. Manual reclosing of the switch 10 is achieved by clockwise pivoting of the handle 42.

Referring to figure 4, the relay 98 of the differential trip device 46 and the differential fault indicator device 100 are located on the same side of the mounting plate 104 opposite the operating mechanism 96. The relay 98 is of the polarised permanent magnet type, comprising an excitation coil electrically connected to the secondary winding 140 of the differential transformer 62. The movable armature of the relay 98 can cooperate (see arrow F1) with a trip bar 142 capable of actuating the latch 128 to the tripped position, when a differential fault occurs. An auxiliary resetting lever 144 of the relay 98 is pivotally mounted on a spindle 146, and is biased counterclockwise (see arrow F2) by a torsion-type resetting spring 148. The pivoting plate 56 of the operating mechanism 96 is equipped with a neutralising protrusion 150 (see figure 1) designed to cooperate with the resetting lever 144

when closing is performed by means of the handle 42, in such a way as to move the lever 144 away from the armature after the relay 98 has been reset.

On the same spindle 146 of the resetting lever 144 an indicator lever 152 is mounted having one end arranged as a mechanical fault indicator 154, and an opposite end bearing a latching nose 156 operating in conjunction with an indicator latch 158, mounted with limited rotation on a spindle 160. A return spring 162 is wound on the spindle 160 and biases the indicator latch 158 counterclockwise. The trip bar 142 acting as operating device between the relay 98 and the main latch 128 of the mechanism 96 also cooperates with the indicator latch 158 of the indicator device 100 when a differential tripping order is emitted by the relay 98.

The conventional wiring diagram of the test circuit 94 (see figure 5) comprises, serially connected, the differential fault simulation resistor 92, a test switch 166 actuated by the test button 44, and a protective switch 168 automatically opening the test circuit 94 when the movable contacts 50, 66 of the switch 10 are opened. Electrical connection of the test circuit 94 is made at a first connection point 170, situated between the neutral movable contact 66 and the toroid, and at a second connection point 172 located between the toroid and the output terminal 22 of the phase circuit 36.

The embodiment of the test circuit 94 illustrated in figures 3 and 4 shows the test push-button 44 housed in a cavity 174 of the insulating cover 14. A compression return spring 176 is inserted between the test button 44 and the bottom of the cavity 174. The test button 44 bears a pair of contact blades 178, 180 of different lengths, the longer one 178 cooperating with a ramp 182 of the neutral movable contact 66, and the shorter one 180 with a connecting conductor 184 of the resistor 92. It can be

noted that the blade 178 and the ramp 182 constitute the protective switch 168, and that the blade 180 and conductor 184 form the test switch 166. Pressing the test button 44 causes simultaneous closing of the two switches 166, 168, resulting in the flow of an artificial fault current detected by the differential transformer 62. The current in the test circuit 94 is interrupted when the neutral movable contact 66 is opened by the ramp 182 moving away from the blade 178, even if the test button 44 remains depressed.

Operation of the mechanism 96 with differential trip device 46 of the two-pole switch 10 is as follows :

- in the closed position (not represented) of the switch 10, the handle 42 is on the right in figure 1, and the main latch 128 of the mechanism 96 locks the latching nose 126 of the catch 120. The opening spring 110 of the mechanism 96 is fully compressed, and the resetting lever 144 of the relay 98 is separated from the armature by a gap due to the neutralising action of the protrusion 150 at the top end of the plate 56. The indicator 154 occupies an inactive position, and the indicator lever 152 is latched to the indicator latch 158.

When a manual opening order is given by means of the handle 42, clockwise pivoting of the plate 56 causes the phase 50 and neutral contacts 66 to open, the main latch 128 remaining in the locked position (see figure 1). The protrusion 150 of the plate 56 moves away from the resetting lever 144, and the spring 148 urges the lever 144 to the set position in engagement with the armature of the relay 98. The indicator lever 152 latched to the indicator latch 158 remains immobile during manual opening of the mechanism 96.

From the closed position, the occurrence on the mains system of a real insulation fault or an artificial one by means of the

test circuit 94, is detected by the differential transformer which sends a tripping order to the relay 98 of the differential trip device 46. The movement of the armature causes a leftwards translation of the trip bar 142 (arrow F1 in figure 4), bringing about a combined unlocking movement of the main latch 128 and of the indicator latch 158.

This results in the contacts 48, 50 ; 64, 66 of the two-pole switch 10 opening due to the action of the spring 110, and the indicator lever 152 pivoting counterclockwise to an active fault indication position. This position is visible from outside via a window arranged in the front panel of the cover 14. During the opening movement of the mechanism 96, automatic resetting of both the catch 120 with the main latch 128, and of the relay 98 by the resetting lever 144 takes place. The handle 42 occupies the position represented in figure 1, and the indicator lever 152 remains permanently in the active fault indication position.

Manual movement of the handle 42 from the open position to the closed position brings about reclosing of the contacts 48, 50 ; 64, 66, moves the resetting lever 144 of the relay 98 to a neutralising position, and resets the indicator lever 152 to the inactive position. This control of the levers 144, 152 is achieved by the direct action of the protrusion 150 of the plate 56, whose position corresponds to the actual position of the movable contacts 50, 66.

The two-pole differential switch 10 can be used in a single-phase mains system with neutral, or on two phases of a multipole mains system. The range covers powers from 25 A to 63 A, and the sensitivities of the differential trip device 46 can range from 10 mA to 500 mA in classes AC and A.

According to the alternative embodiment in figure 6, the two-pole differential switch is equipped with a high-speed making

device 200 comprising a latching lever 202 mounted with limited pivoting on a fixed spindle 204 of the mounting plates 102, 104. The latching lever 202 retains the end of the support arm 52 during a first part of the closing travel of the handle 42. In a second part of the closing travel, the pivoting plate 56 acts on an unlocking ramp 206 of the latching lever 202 so as to lift and release the support arm 52 to achieve high-speed closing of the movable phase contact 50. A return spring biases the latching lever 202 to the position retaining the support arm 52.

CLAIMS

1. A two-pole differential switch with a moulded insulating case (12) housing :

- a pair of separable contacts (48, 50 ; 64, 66) per pole, comprising a stationary contact (48, 64) and a movable contact (50, 66) in electrical connection with a pair of connection terminals (24, 22 ; 28, 26),

- an operating mechanism (96) having a mechanical transmission link arranged between a handle (42) and a device for driving the two movable contacts (50, 66),

- a spring (110) actuating the mechanism (96) to bring about opening of the contacts when an automatic trip takes place on a fault,

- a differential trip device (46) having a summing transformer (62) for detection of a fault current, and a trip relay (98) designed to cooperate with a main latch (128) of said mechanical link of the mechanism (96),

- and an automatic resetting device of the relay (98) after tripping, comprising a resetting lever (144),

characterized in that the switch comprises in addition a differential trip indicator lever (152) forming part of a differential fault indicating device (100), said indicator lever cooperating by latching with an indicator latch (158) controlled by the relay (98), said indicator lever (152) being capable of occupying either a stable active fault indication position after the indicator latch (158) has been unlatched by the relay (98), or a stable inactive position after the indicator latch (158) has been relatched by manual movement of the handle (42) to the



closed position, that when tripping occurs the relay (98) cooperates with the main latch (128) of the mechanism (96), and with the indicator latch (158) of the indicator lever (152) via a common trip bar (142), that the relay (98) is arranged side-by-side with the operating mechanism (96) in the case (12), and that after the relay (98) has been reset a protrusion (150) of the device for driving the movable contacts (50, 66) comes into engagement during the closing travel of the handle (42), with the resetting lever (144) to move it against the return force of a resetting spring (148) to a neutralisation position, enabling another trip to be performed by the differential trip device (46).

2. The differential switch according to claim 1, characterized in that the resetting lever (144) of the relay (98), and the differential tripping indicator lever (152) are pivotally mounted on a common spindle (146), extending parallel to the pivoting axis (160) of the indicator latch (158), that the device for driving the movable contacts (50, 66) is formed by a pivoting plate (56) biased to the opening direction by the actuating spring (110), and that the support arms (52, 68) of the movable contacts (50, 66) are mounted on a common spindle (54) which is securedly united to said plate (56).

3. The differential switch according to claim 2, characterized in that the resetting lever (144) of the relay (98) is inserted between the plate (56) of the mechanism (96) and the differential tripping indicator lever (152), and that driving of the resetting lever (144) by the protrusion (150) of the plate (56) to the neutralisation position simultaneously causes the indicator lever (152) to be moved from the active position to the inactive position after tripping.

4. The differential switch according to one of the claims 1 to 3, wherein the insulating case (12) is formed by assembly of a



cover (14) and a base (16), characterized in that the base (16) acts as a housing for the summing transformer (62), for the pairs of contacts (48, 50 ; 64, 66) and for the connection terminals (24, 22 ; 28, 26), whereas the cover (14) houses the operating mechanism (96), the differential trip device (46) with relay (98) and the differential fault indicator device (100).

5. The differential switch according to claim 4, wherein the case (12) is of parallelepipedic shape, characterized in that the input terminals (24, 28) and output terminals (22, 26) are housed two by two in recesses (30) located at the four opposite corners of the base (16), and that the internal volume of the base (16) is subdivided by two longitudinal walls (80, 82) and a transverse wall (84) into a plurality of independent compartments (74, 76, 78, 90), comprising :

- the compartment (78) housing the summing transformer (62) extending over the whole width of the base (16) and being arranged between the output terminals (22, 26) and the transverse wall (84),

- two juxtaposed compartments (74, 76) housing the phase (36) and neutral circuits (38), located between the input terminals (24, 28) and the transverse wall (84),

- and a compartment (90) housing the test resistor (92) of the test circuit (94) associated with the differential trip device (46), said compartment (90) being disposed widthwise between the compartment (76) housing the neutral circuit (38) and one of the side faces (88) of the base (16).

6. The differential switch according to claim 5, characterized in that the summing transformer (62) comprises a magnetic circuit in the form of a toroid extending perpendicularly to the large side faces (86, 88) of the base (16), and being located



under the operating mechanism (96) and the trip relay (98).

7. The differential switch according to one of the claims 2 to 6, characterized in that a high-speed making device (200) comprises a latching lever (202) mounted with limited pivoting on a fixed spindle (204), so as to retain the support arm (52) of the movable contact (50) during a first part of the closing travel of the handle (42), the latching lever (202) an unlocking ramp on which the pivoting plate (56) acts in the second part of the closing travel to release the support arm (52), resulting in high-speed closing of the phase movable contact (50).

8. The differential switch according to one of the claims 5 to 7, comprising a test circuit (94) with push-button (44) designed to insert a test resistor (92) to simulate a differential current to test the correct operation of the differential trip device (46), characterized in that the push-button (44) of the test circuit (94) is housed in a cavity (174) of the cover (14) and bears a dual testing (166) and self-protective (168) switch constituted by two contact blades (178, 180) cooperating respectively with one (66) of the movable contacts of the switch (10), and with a connecting conductor (184) of the test resistor (92), the test circuit (94) being automatically switched out of operation as soon as said movable contact (66) moves from the closed position to the open position, and that the two contact blades (178, 180) are of different lengths, the longer blade (178) cooperating with a ramp (182) of the neutral movable contact (66).

