

CURRENT LIMITING CIRCUIT BREAKER

This invention relates to a multipolar electric circuit-breaker, comprising per pole :

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- a pair of separable fixed and movable contacts,

- an arc-control chamber of an arc drawn between the separable contacts,

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- a contact arm in electrical conductive material carrying the movable contact, and series connected to said contacts,

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and an electromagnetic device with a U shaped magnetic main circuit, having two wings, separated by a first air gap (E), extending transversely to the longitudinal direction of arm and susceptible to exert on the contact arm electromagnetic forces, generated by the interaction of the current flowing in said arm and the magnetic flux generated by said current in the magnetic circuit to provoke the rapid contacts opening.

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A well-known circuit-breaker of the kind mentionned (US 3 815 059) comprises a plurality of U shaped ferromagnetic tongues, alined to form an opened slot of positionned contact arm, extending according to a direction, perpendicular to the plane of tongues. The electromagnetic forces, generated by the fault current, provoke the rapid drive of the arm inside the slot and contacts opening, with a fault current limitation. When the circuit-breaker has a big size, it is difficult to maintain a controlled electrodynamic holding of the contacts until a predetermined current value without increasing contact pression, which would necessitate an overdimensioned operating mechanism.

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From FR. A 2 246 052, there is known an electromagnetic trip device having a coil and two plates, one of them actionning the interlocking safeguard of the circuit-breaker, and the

other one operating directly on the movable contact. A saturable magnetic shunt overlaps the air-gap of working plate operating on the movable contact to ensure a successive action of the two plates. The device is elaborate and necessitates a magnetizing coil.

The invention aims at overcoming these disadvantages and realizing a controlled electrodynamic holding circuit-breaker, until an over-current threshold and rapidly limiting beyond.

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In accordance with the present invention, the circuit-breaker is characterized by the fact that said magnetic circuit comprises a saturable shunt circuit, comprising a pair of ferromagnetic tongues of reduced section, relatively to that of the wings and separated by a second air-gap (e) to constitute in a non-saturated state a magnetic shunt of lower reluctance than the main circuit reluctance and to provoke in a saturated state the magnetic flux flow across said first air-gap (E) for moving the contact arm towards the opened position by the electromagnetic forces, the passage of the saturable circuit from the non-saturated state to the saturated state occurring when the fault current, flowing in said arm is higher than a predetermined threshold.

25 When the circuit-breaker operates normally, the current flowing in the contact arm generates a magnetic flux in the magnetic circuit having a lower value than the saturation value of the shunt magnetic circuit. Almost the totality of the flux takes this shunt circuit of lower reluctance and the electromagnetic device exerts on the contact arm an attractive force which is unimportant.

When there is a short-circuit, the shunt circuit becomes saturated and the flux crosses the air-gap (E), holding the contact arm which is rapidly attracted. The shunt circuit establishes a clear threshold of operation of the limiting electromagnetic device and this threshold, determined by the section of the

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shunt circuit, is chosen fairly equal to the threshold of the electromagnetic tripping device, or an instantaneously operating release of the circuit-breaker, which provokes the ultimate opening of the contacts, following the rapid separation generated by the electromagnetic device.

The circuit-breaker is advantageously a multipolar circuit-breaker with a moulded case, having an operating toggle mechanism and an electromagnetic and thermal automatic tripping device, ensuring the opening of the contacts, when a fault current or a short-circuit appears. The electromagnetic device of rapid opening becomes active when a short-circuit current occurs, to change the intermediary opening position of the movable contact, and the operating mechanism, driven by the electromagnetic tripping device, then relays to move the contact arm from the intermediary position (1) to the definitive opening position (0).

Other objects and advantages will become apparent from the following description of an embodiment of the invention, when read in conjunction with the accompanying drawings in which :

- figure 1 is a longitudinal sectional view of one pole of the current limiting circuit-breaker, constructed in accordance with the invention and shown in the ON position ;

- figure 2 shows the pole of figure 1, respectively in an intermediary position I (fine lines) and in the OF position (thick lines) ;

- figure 3 is a perspective view of the magnetic opening device of the pole of figure 1 ;

- figure 4 is a top view of the movable contact arm positioned within the magnetic opening device.

With reference to the drawings, a circuit-breaker has a moulded case 12 comprising a base 14 and a cover 16 and containing a trip unit 15 and an operating toggle mechanism 17 common to the various poles, for instance to the three poles of the circuit breaker. Electrically connected to a terminal 20 by a conductor 21 is a fixed contact 18, which cooperates with a movable contact 22 mounted upon a contact arm 28. The contact arm is electrically connected to a terminal 24 by a woven shunt 26 and a conductor 27. An arc extinguishing structure 34 with plates 36 is disposed in proximity to the contacts 18, 22, in such a manner that an arc formed between contacts 18, 22, is rapidly driven along an arcing rail 38 towards the arc extinguishing structure 34.

Contact arm 28 is pinned in its middle 50 by a pin 48 to a generally U-shaped bracket 30. Pin 48 is rigidly secured in openings 52 provided in the side flanges 54 of the bracket 30 and allows for a small rotation of contact arm 48 (fig. 4). The brackets 30 for the three poles are fixedly secured to a common tie bar 32 and the tie bar 32 is mounted for pivotal movement between open and closed positions. The toggle mechanism 17 is pivotally connected to the center pole contact arm bracket 30 to move all of the three contact arms 28 to the open or closed position. The circuit breaker is manually operated by movement of the handle 40 which passes through an opening 42 in cover 16 and actuates the operating toggle mechanism 17. The circuit breaker is automatically tripped by operation of the trip unit 15 including a first trip member 11, for instance a bimetal member causing a thermal tripping operation upon occurrence of a moderate overcurrent condition through the circuit breaker and a second trip member 13, for instance an electromagnetic trip member causing an electromagnetic tripping operation upon occurrence of an overcurrent condition above a predetermined magnitude SM more severe than the previously mentioned moderate overcurrent condition. Such a moulded case circuit breaker is well known.

In accordance with the present invention, a magnetic device 44 includes a generally U-shaped yoke 46 of magnetic material such as iron, the bottom part 56 of this yoke 46 being fixedly secured and positioned by means of pins 58, 60, to the base 14 of the moulded case 12. The two side flanges or pole pieces 62, 64, of the yoke 46 form a channel having an open top in the contact opening direction. A length L of the contact arm 28, located between the pin 48 and the shunt 26 extends into the channel of the yoke 46. The length L corresponds to the length of the pole pieces 62, 64. The yoke 46 comprises a pair of parallel legs 66, 68 secured at the free ends of the pole pieces 62, 64 and extending in the contact opening direction. The length l of the legs 66, 68, is shorter than the length L of the pole pieces 62, 64 and the free ends 70, 72 of the legs 66, 68 are bent to form a magnetic bight part having an air gap e. This air gap e is smaller than the air gap E between the pole pieces 62, 64, and may be zero.

When the contacts 18, 22 are closed, the contact arm 28 extends in proximity to the free ends of the pole pieces 62, 64, and a current flowing through the contact arm 28 generates a magnetic flux in the yoke 46. As can be seen in fig. 3, the flux takes two pathes, a flux path $\Phi 2$ which crosses the air gap E and flows in the iron of the bottom of the yoke 46 and another flux path $\Phi 1$ of lower reluctance which crosses the air gap e and flows in the iron of the legs 66, 68, and of the yoke 46. The iron section of the legs 66, 68 is small and this will cause the iron of the flux path $\Phi 1$ to saturate first. The saturation occurs when the current I flowing in the contact arm 28 is higher than a predetermined value corresponding to the electromagnetic trip magnitude SM. After saturation of the flux path $\Phi 1$, the flux flow across the air gap E increases. The contact arm 28 carrying current is located in the magnetic field in the air gap E and the electromagnetic force generated by the interaction between the current flow in the contact arm 28 and the magnetic flux in air gap E acts to move the contact arm 28 towards the bottom of the yoke to separate

the contacts 18, 22. A spring 74 positioned between the side flanges 62, 64, urges the contact arm 28 for engagement of the movable contact 22 with the fixed contact 18. The bight part 70, 72, of the yoke 46 limits counterclockwise rotation of the contact arm 28 about the pivot pin 48.

This device operates as follows :

When the circuit breaker is in the closed circuit position, shown in fig. 1, the spring 74 urges the movable contact 22 in engagement and the contact arm 28 extends through the air gap E in the area of the free ends of the pole pieces 62, 64, for instance slightly above these free ends. Upon the occurrence of normal current conditions and moderate overcurrent conditions up to the predetermined magnitude SM, practically all of the flux generated in the yoke 46 flows in the flux path $\Phi 1$ across the air gap e of smaller reluctance than flux path $\Phi 2$. The flux density in the air gap E is very small, so that the contact arm 28 remains in the closed position. The magnetic device 44 does not intervene. The moderate overcurrent causes heating of the bimetal member and a thermal tripping operation in a well known manner.

Upon the occurrence of a fault current, such as a short circuit current, exceeding the predetermined threshold value SM, the iron of the legs 66, 68 saturates rapidly and the magnetic flux flow is diverted in the flux path $\Phi 2$, across the air gap E. The current-carrying contact arm 28 will have a force acting on it, which causes the contact arm 28 to move across the magnetic field towards the bottom of the yoke 46. This electromagnetic force overcomes the force of spring 74 and the contact arm 28 rotates clockwise about the pin 48 causing separation of the movable contact 22 from the fixed contact 18. This force provides a high initial acceleration and brings quickly the contact arm 28 from rest to high velocity. The rapid contact separation creates a current limitation. As the current value exceeds the predetermined magnitude SM of



the electromagnetically operable tripping member 13, the latter is energized at the same time to collapse the toggle mechanism 17 and to move the brackets 30 to the open position. The electromagnetic force moves rapidly the movable contact 22 in the intermediary position I shown in fig. 2 in fine lines and the magnetic tripping initiates the full opening of the circuit-breaker (fig. 2, thick lines).

The magnetic device 44 causes a straightforward opening of the contacts 18, 22, without erratic movements thereof. Contact arm 28 is advantageously of non magnetic conductive material, but may be of ferromagnetic material in which case the air gap E would be modified. The generally U-shaped yoke 46 may cooperate with the front part of contact arm 28 and correspondingly been positioned above this contact arm.



CLAIMS

1. A multipolar electric circuit breaker comprising per pole:
 - a pair of separable fixed (18) and movable (22) contacts,
 - 5 - an arc-control chamber (34) of an arc drawn between the separable contacts,
 - a contact arm (28) in electrical conductive material carrying the movable contact, and series connected to said contacts (18, 22),
 - 10 - and an electromagnetic device (44) with a U-shaped magnetic main circuit (46) having two wings (62, 64) separated by a first air gap (E) extending transversely to the longitudinal direction of arm (28) and susceptible to exert on the contact arm electromagnetic forces generated by the
 - 15 interaction of the current (I) flowing in said arm (28) and the magnetic flux ($\vec{B}_2$) generated by said current in the magnetic circuit (46) to provoke the rapid contacts opening,
 - characterized by the fact that said magnetic circuit comprises a saturable shunt circuit (66, 68) comprising a pair
 - 20 of ferromagnetic tongues (66, 68) of reduced section relatively to that of the wings (62, 64) and separated by a second air gap (e) to constitute in a non saturated state a magnetic shunt of lower reluctance than the main circuit reluctance and to provoke in a saturated state the magnetic
 - 25 flux flow across said first air gap (E) for moving the contact arm (28) towards the opened position by the electromagnetic forces, the passage of the saturable circuit from the non saturated state to the saturated state occurring when the fault current flowing in said arm is higher than
 - 30 a predetermined threshold (S_M).
2. Electric circuit breaker according to claim 1, characterized by the fact that a compression spring (74) positioned insides the U-shaped magnetic circuit (46) urges
- 35 contact arm (28) in the closed position with a suitable contact pressure up to said predetermined current threshold (S_M).



3. Electric circuit breaker according to one of the claims 1 and 2, characterized by the fact that the associated wings (62, 64) and tongues (66, 68) of the magnetic circuit (46) are symmetrical to the median oscillation plane of said movable contact and that the extremities (70, 72) of said tongues are bended at right angles to constitute abutments limiting the contact arm (28) pivotment.
4. Electric circuit breaker according to any one of the claims 1 to 3, comprising an operating toggle mechanism (17) having a trip lever to actuate the movable contact (22) between the closed (F) and opened (O) contact positions (18, 22) and an automatical trip device (15) associated to the operating mechanism for the simultaneous contact (18, 22) opening when the current is higher than said predetermined threshold (S_M), characterized by the fact that after passing said threshold (S_M) said electromagnetic device (44) moves the contact arm (28) at high speed towards an intermediate contact (18, 22) separation position (I) and that thereafter the operating mechanism (17) monitored by the trip device (15) works in relay of the electromagnetic device (44) to move the contact arm (28) from the intermediate position (I) towards the final opened position (O).
5. Electric circuit breaker according to claim 4, characterized by the fact that the saturation threshold (S_M) of the saturable shunt circuit corresponds substantially to the trip threshold of the instantaneous trip device (15) so that the circuit breaker has controlled electrodynamic holding of the contacts (18, 22) when the electromagnetic device is in an inactive position, up to said thresholds (S_M) and thereafter a fault current limitation due to the high speed contact arm (28) movement towards the intermediate position (I) by the electromagnetic forces generated by the electromagnetic device (44) after passing said Thresholds (S_M).