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(54) CIRCUIT INTERRUPTER

(71) We, TERASAKI DENKI SANGYO KABUSHIKI KAISHA, of No. 27, Showa-cho-naka 5-chome, Abeno-ku, City of Osaka, Japan, a Body Corporate organized and existing under the Law of Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to improvements in a circuit interrupter of the type wherein upon the occurrence of a short-circuit current, an electromagnetic repulsion generated between a pair of movable contact arms is utilized to separate them rapidly from each other thereby to decrease an interruption time and give a current limiting effect.

For circuit interrupters of the type utilizing such an electromagnetic repulsion to rotate a pair of movable contact arms in opposite directions, it is necessary to bring the contact arms thus rotated into their normal open positions, i.e. those resulting from the operation of the associated operating or over-current responsive trip mechanism so that they are ready for the succeeding closing operation.

According to the invention, there is provided a circuit interrupter comprising a pair of movable contact arms disposed in substantially parallel relationship in the closed position of the interrupter, each of said contact arms being provided at one end with a contact and pivotably mounted at the other end on a pivot pin, spring means individual to each contact arm to normally apply a contact pressure to the associated contact, an operating mechanism for moving one of said movable contact arms between its closed and open positions, the said one of the contact arms being pivotably mounted to a pivotable holder connected to the operating mechanism, thermally and electromagnetically responsive trip means operatively coupled to

said operating mechanism, the arrangement being such that a flow of greatly excessive current through the interrupter will generate an electromagnetic repulsion between the arms thereby to pivot at least one of the arms independently of the trip means to interrupt the current, the last-mentioned arm or arms when pivoted being held in the open position by reversal of the direction of the force exerted by respective associated spring means, said trip means being arranged and adapted to perform a tripping operation shortly after said contact arms have separated from each other and so to cause the normal constrained state of the operating mechanism to collapse thereby automatically by pivoting of the holder by the operating mechanism, to restore to its original direction the force exerted by the spring means and thereby bring said contact arm or arms into the position resulting from normal operation of the trip means.

Preferably the one movable contact arm is pivotably mounted to a pivotable holder and a reset element of electrically insulating material is movably disposed in slightly spaced relationship between the holder and the other contact arm at the ends thereof remote from the respective contacts. As the constrained state of the operating mechanism collapses due to the operation of the trip means the holder is rotated to push the reset element against the other contact arm bring it in its tripped position, as well as bringing the one of the contact arms to its tripped position.

The invention will become more readily apparent from the following detailed description taken in conjunction with the accompanying drawings in which:—

Figure 1 is an elevational sectional view of a circuit interrupter embodying the invention, in its closed position;

Figure 2 is a fragmental side elevational view illustrating the movement of the mov-

able contact arms of the interrupter from their closed positions to their open positions under the action of an electromagnetic repulsion generated between the contact arms due to the flow therein of a short-circuit current;

Figure 3 is a fragmental side elevational view of the movable contact arms after they have been fully opened to interrupt a short-circuit current;

Figure 4 is a view similar to Figure 3 but illustrating a pair of movable contact arms in their tripped positions;

Figure 5 is a fragmental perspective view of one of the movable contact arms shown in Figures 1 to 4 inclusive; and

Figure 6 is a plan view of a resetting element constructed in accordance with the invention.

While the invention is applicable to current interrupters having any desired number of poles it will now be described in conjunction with a three pole circuit interrupter the construction of the central pole thereof being illustrated.

Figure 1 shows an interrupter which comprises a housing open at one end, the upper end as viewed in Figure 1, a cover member 12 detachably secured to the housing 10 at the open end, and a pair of movable contact arms 14 and 16 disposed generally parallel to and facing each other within the housing 10. The housing 10 and cover member 12 are moulded of any suitable electrically insulating material and the contact arms 14 and 16 are composed of any suitable electrically conductive material. Each of the first and second contact arms 14 and 16 respectively is provided at one end with a contact 18 or 20 respectively. When in their closed positions, as shown in Figure 1, the contact arms 14 and 16 are substantially parallel.

The first contact arm 14 is pivotably mounted by a pin 22 to a contact holder 24 which is, in turn, pivotably mounted on a pivot pin 26 supported to a bracket 28. The contact holder 24 has fixed at its upper end a connecting rod 30 of any suitable electrically insulating material to which the contact holders for the other poles (not shown) are connected. The first contact arm 14 is movable between its closed and its normal open positions by an operating mechanism which will be described hereinafter.

The first contact arm 14 includes a pair of parallel contact springs 32 each having one end anchored to a spring shoe 34 loosely engaging a pin 36 secured to the contact arm 14 at a position located to the left of the pin 22 as viewed in Figure 1 and the other end anchored to a spring shoe 38 loosely engaging a pin 40 secured to the contact holder 24 at a position located to the right of the said pin 22 as viewed in Figure 1. With the interrupter in its closed position, the con-

tact springs 32 serve normally to exert on the first or upper contact 18 a contact pressure under which the contact 18 is maintained in contact with the mating contact 20. However a short-circuit current flowing through the circuit interrupter will generate an electromagnetic repulsion between the first contact arm 14 and the substantially parallel second contact arm 16 to separate the arms, and the contact springs 32 will then move their line of action above the pin 22 to pull the first contact arm 14 to its open position independently of an operating mechanism therefor, and maintain it in this open position.

As shown in Figure 1, a stop 28a is rigidly secured to bracket 28 to determine the open position of the first contact arm 14. It is to be noted that the stop 28a is operatively associated only with that pole of the circuit interrupter including the fixture block, i.e. in the illustrated example, with the central pole of the three pole interrupter, while for each of the other poles a protrusion 12a is disposed on the internal wall surface of the cover member 12 at a position such that all the first contact arms such as 14 are substantially aligned with each other in their open positions. Further, in order to prevent an excessive rotation of the first contact arm 14 about the axis of the pin 22 in the closing direction, i.e. counter-clockwise as viewed in Figure 1, by the action of the contact springs 32, the contact holder 24 is provided at one end near to the associated contact with an abutment 22a facing the pin 36 and the contact holder 24 is also provided at the other end with an overhang 24b for a purpose that will become apparent hereinafter.

The second or lower contact arm 16 is pivotably mounted to a support 42 by a pivot pin 44 and has a pair of reversing levers 46 disposed in spaced, parallel relationship one on each side of arm 16. The support 42 is rigidly secured to the bottom surface of the housing 10. Each reversing lever 46 is pivotably supported at one end near the contact 20 on a pivot pin 48 disposed on the support block 42, and is provided in the middle with an L-shaped slot 50. The other ends of the reversing levers 46 are connected together by a pin 52 and a pair of spring shoes 54 loosely engage the pin 52 at both ends (see Figure 5). A pin 56 extends through the middle portion of the lower contact arm 16 against movement and has secured at each end a spring shoe 58 to which a respective contact spring 60 is anchored. The contact springs 60 have the other ends anchored to the spring shoes 54. To drive the reversing levers 46, the second contact arm 16 further comprises a driving pin 62 movably inserted into the slots 50 in the reversing levers 46.

Like the first contact arm 14, the second

contact arm 16 is operatively associated with a stop 64 disposed on the support 42 to prevent excessive rotation of the second contact arm 16 about the axis of the pin 44 in the closing direction, i.e. clockwise as viewed in Figure 1.

The second contact arm 16 is electrically connected through a flexible electrical conductor 66 to an electrical conductor 68 adapted to be electrically connected to a source of electrical power (not shown). The first contact arm 14 is electrically connected through a flexible conductor 70 and a conductor 72 to an intermediate terminal 74 screw-threaded to the housing 10.

With the second contact arm 16 in its closed position as shown in Figure 1, a straight line passing through both anchoring points where each contact spring 60 is anchored to the spring shoes 54 and 58 passes above the axis of the pivot pin 44 whereby the contact springs 60 tend to rotate the second contact arm 16 about the axis of the pivot pin 44 in the clockwise direction as viewed in Figure 1 thereby to maintain that arm under a predetermined pressure under which the second or lower contact 20 is in engagement with the first or upper contact 18. The said straight line also passes above the axis of the pivot pins 48 of the reversing levers 46 so that the latter tend to rotate counter-clockwise about the axis of the pin 48. Thus the first and second contact arms 14 and 16 respectively are firmly maintained in their closed positions when the pivot pin 44 is in engagement with the lowest portion of the L-shaped slot 50.

Upon the occurrence of a short-circuit current flowing through the circuit interrupter and consequent electromagnetic repulsion between the arms 14 and 16, the arm 16 can rotate about its axis of rotation in the counter-clockwise direction as viewed in Figure 1 under the action of the said electromagnetic repulsion until it abuts against the stop 64.

An H-shaped reset element 76 of any suitable electrically insulating material (see Figure 6) is disposed between the overhang 24b of the contact holder 24 and the adjacent end of the contact arm 16. The support 42 has an extension 42a obliquely and upwardly directed from the right-hand edge (as viewed in Figure 1) toward the overhang 24b and forming a narrow guide passageway 78 with a ramp surface 10a of the housing disposed parallel to the extension 42. The reset element 76 is slidably disposed within the sloping guide passageway 78 in such a manner that the pair of leg portions on the upper side (as viewed in Figure 1) of the H, forming a recess 76a, are disposed adjacent to the overhang 24b while the pair of leg portions on the other side of the H, forming recess 76b, have interposed there-

between the end of the second contact arm 16. The reset element is not physically connected to the contact holder or the second contact arm.

In order to move the upper contact arm 14 between its closed and normally open or tripped positions and *vice versa*, the circuit interrupter includes an operating mechanism 80 which comprises an operating handle 82 movably projecting from the cover member 12, a switching lever 84 secured at one end to the operating handle 82 and pivotably mounted at the other end on a stationary pin 86 secured to the bracket 28, and a pair of toggle link members 88 and 90 articulated by a toggle pin 92. The mechanism further comprises a pair of tension springs 94 spanning between a spring shoe 84a disposed at that end of the switching lever 84 integrally connected to the operating handle 82 and a spring shoe 92a loosely engaging the toggle pin 92. Thus it will be appreciated that the link members 88 and 90, the toggle pin 92 and the springs 94 form a toggle linkage of well known construction.

The operating mechanism 80 is operatively coupled to a trip mechanism 95 of conventional design. The link member 90 engages at 96 a trip lever 98 pivotably mounted at one end on a stationary pin 100 secured to the bracket 28 and engaging at the other end a primary latch 102. The primary latch 102 engages a secondary latch member 104 extending in a casing 106 of any suitable electrically insulating material.

Disposed within the casing 106 is an over-current responsive trip mechanism 105, which comprises a bimetallic element 108 adapted to be heated by an excessive current flowing through a main conductor 110 electrically connected to the intermediate terminal 74, and an instantaneously tripping electromagnet assembly 112 inductively coupled to the conductor 110. The conductor 110 is adapted to be electrically connected to a load (not shown). The remaining components within the casing 106 will be described in conjunction with the description of the operation of the circuit interrupter.

The operation of the arrangement illustrated in Figure 1 will now be described.

If the circuit interrupter is desired to be manually moved from its closed position as illustrated in Figure 1 to its tripped or normally open position, the operating handle 82 is thrown to the "OFF" side, in the right-hand direction as viewed in Figure 1, to cause the constrained state of the two toggle link members 88 and 90 to collapse thereby to permit the pivot pin 22 connecting the first contact rod 14 to the holder 14 to be raised. This causes the first contact 18 to be rotated about the axis of the pin 26 in the clockwise direction as viewed in Figure 1, to

be separated from the second contact 20 and until the interrupter reaches its "OFF" position. The term "clockwise or counter-clockwise direction" used hereinafter means one as viewed in the associated Figure.

The circuit interrupter thus open can be again closed by throwing the operating handle 82 to the "ON" side.

If a normal over-current flows through the interrupter in its closed position, that current flows through the conductor 110 to heat it whereby the bimetallic element 108 is deflected to push against a trip-adjusting screw 114 facing the element 108. This causes a trip-bar 116 to be rotated clockwise to disengage the latch 118 secured to the trip shaft 116 from the secondary latch member 104, followed by clockwise rotation of the secondary and primary latch members 104 and 102. This causes the primary latch 102 to disengage the trip lever 98. Therefore the constrained state of the two toggle link members 88 and 90 collapses to permit the contact holder member 24 to be rotated clockwise about the axis of the pin 26. This rotation of the holder 24 is accompanied by rotation of the first contact arm 14 in the same direction as the holder whereby the contact 18 is moved away from the contact 20, resulting in an interruption of the associated circuit.

If an over-current having a magnitude equal to 5 to 10 times the rated current for the interrupter flows through the latter, the electromagnetic assembly 112 is operated to cause the associated trip rod 120 to rotate the trip shaft 116 clockwise, and the process described above occurs to interrupt the associated circuit.

In the operation of manually opening the interrupter or of tripping it by response of the bimetallic element or the electromagnetic assembly as above described, the contact springs 60 permit the second contact arm 16 only to follow the first contact arm 14 by a very short angular distance sufficient to engage the other end of the contact arm 16 with the associated stop 64. Therefore the second contact arm 16 will remain in a position substantially identical to that illustrated in Figure 1.

If an extraordinarily high current such as a short-circuit current flows in the circuit interrupter, this current flowing through the first and second contact arms 14 and 16, which are substantially parallel, in opposite directions as shown by the arrows in Figure 1, generates a strong electromagnetic repulsion between the arms, which are caused to be instantaneously and simultaneously rotated in opposite directions resulting in interruption of the short-circuit current. It is to be noted that this interrupting operation is performed independently of the over-current responsive trip mechanism 105. In

other words, the holder 24 is maintained in its closed position by means of the operating mechanism 80 whereas the first contact arm 14 is rotated clockwise about the axis of the pin 22 by the action of the electromagnetic repulsion until the line of action of the contact springs 32 passes upwardly through the pin 22 whereupon its force is reversed in effect to rotate arm 14 and maintain it in its open position as shown in Figure 3 where the arm abuts at one end against the stop 28a. Simultaneously with the initiation of rotation of the first contact arm 14 as above described, the second contact arm 16 also begins to rotate about the axis of the pin 44 in the opposite or counter-clockwise direction under the action of the electromagnetic repulsion, as shown in Figure 2. During this rotational movement of the second contact arm 16, the axis of the spring pin 56 has been moved from a position A to B as shown in Figure 2, whereupon the line of action of the contact springs 60 coincides with a line passing through the positions B and A' of the axes of the pins 56 and 52. At the instant that the line of action of the springs 60 passes below the axis of the pin 48, the reversing levers 46 tend to be rotated clockwise about the axis of the pin 48. However friction at the pin 48 is effective to still hold the spring pin 52 at the position A'.

As the second contact arm 16 is further rotated, the axis of the spring pin 56 reaches a position C whereupon the driving pin 62 secured to the second contact arm 16 to drive the reversing levers 46 abuts against the lower edge of the L-shaped slots 50 in the levers to depress them in the clockwise direction. A further rotation of the second contact arm 16 causes the reversing levers 46 to begin to be abruptly rotated in the clockwise direction. As the spring pin 52 approaches a position D' as shown in Figure 3 from the position A' the line of action of the contact springs 60 rapidly approaches the pivot pin 44, so that the clockwise torque on contact arm 16 due to the springs 60 rapidly decreases. This is very effective for decreasing the force opposing the electromagnetic repulsion between the contact arms.

Then the spring pin 56 passes through a position G (see Figure 3) to a position D while the line of action of the contact springs 60 is moved below the pin 44. Therefore the contact spring 60 exerts on the second contact arm 16 a force tending to rotate it counterclockwise, which force then cooperates with the electromagnetic repulsion as previously described to move the second contact arm 16 rapidly to its position illustrated in Figure 3, resulting in interruption of the associated circuit.

The spring pin 56 is moved from position H to position G as shown in Figure 3 so that the line of action of springs 60 is moved

below the pin 48 whereby the reversing levers 46 are rotated clockwise about the axis of the pin 48 so that pin 52 moves from position A to the position D illustrated in Figure 3 at which the pin 44 engages the upper edge of the L-shaped slot 50 in each lever 46.

After the first and second contact arms have performed an automatic interruption operation in the manner above described, the over-current responsive trip mechanism 105 is adapted to be operated with a very small time delay.

As previously described, the operation of the over-current responsive trip mechanism 105 is accompanied by collapse of the constrained state of the operating mechanism 80 to cause the toggle link members 88 and 90 to raise the pin 22. This permits the holder 24 to rotate about the axis of the pin 26 in the clockwise direction (Figure 1). At the same time the first contact arm 14 is rotated counter-clockwise about that point thereon engaging with the stop 28a or the protrusion 12a as the case may be. During this rotation the line of action of the contact springs 32 passes downwardly past the pin 22 after which the first contact arm 14 is downwardly rotated about the axis of the pin 22 and with respect to the holder 24 until the arm returns to its normal open or tripped position as shown in Figure 4.

The clockwise rotation of the holder 24 about the axis of the pin 26 due to the operation of the toggle link members 88 and 90 is also accompanied by the overhang or striker 24b on the other end thereof acting upon the adjacent end 16a of the second contact arm 16 through the reset element 76. This causes the second contact arm 16 to be rotated clockwise about the axis of the pin 44 thereby to move the spring pin 56 from the position D (see Figure 3) past position H whereupon the line of action of the contact springs 60 passes through the axis of the pin 44 to cause the springs 60 to restore the second contact arm 16 to its position illustrated in Figure 4 which position coincides with its closed position.

During this returning movement of the second contact arm 16, the spring pin 56 reaches the position H (see Figure 4) to pass the line of action of the springs 60 through the axis of the pin 48. Substantially simultaneously with this passage, the driving pin 62 abuts against the upper edge of the L-shaped slots 50 to raise the reversing levers 46. This causes the reversing levers 46 to rotate counter-clockwise thereby to return the spring pin 52 to a position A¹ to bring the line of action of the springs 60 on the line A—A¹ until the second contact arm 16 is stopped in its tripped position as illustrated in Figure 4.

Therefore the succeeding closing opera-

tion be performed in the conventional manner, that is, the operating handle 82 can be manually thrown to the "OFF" side to reset the interrupter, then the handle 82 will be manually brought into the "ON" position to perform the closing operation.

From the foregoing it will be appreciated that while the present interrupter is of the one point interruption type the first and second contact arms can be separated from each other by a distance larger than the normal separation therebetween upon the occurrence of an extraordinarily excessive current such as a short-circuit current. This establishes a sufficient interruption distance to improve the current limiting effect as in the two point interruption type of circuit interrupters. In addition, after the current limiting effect has been exhibited, the first and second contact arms are automatically and substantially simultaneously brought into their normal open or tripped positions, whereby the circuit interrupter is ready for the succeeding closing operation. This contributes to great improvements in performance of circuit interrupters utilizing electromagnetic repulsion.

That end 24b of the holder 24 remote from the contact 18 overhangs the reset element 76 to impart to the latter a stroke sufficient to return the second contact arm 16 to its closed position. Also the reset element 76 is held separated from the contact arms 14 and 16 and/or holder 24 so as to effectively utilize an impulse due to the trip operation to return the second contact arm to its closed position and prevent damage due to such an impulse. In contrast, the conventional type of circuit interrupter having a reset element physically connected between a first contact arm or its holder and a second contact arm has the disadvantage that any impulse due to a trip operation could damage the connection of the reset element and the contact arm or its holder, as well as complicating the assembly of the interrupter.

In order to operate the reset element smoothly and efficiently, the striker 24b and the struck surface of the second contact arm 16 are required to be disposed substantially normally to the plane of the reset element 76. With the reset element disposed obliquely to the general bottom surface of the housing, the guide passageway for the reset element must be formed in a complicated manner because the direction of the passageway does not coincide with the standard direction in which the resulting moulding is removed.

In the interrupter described, however, the reset element 76 is slidably held within the guide passageway 78 confined by the tilted wall surface 10a of the housing 10 and the extension 42a folded from the support 42 thereby to be separated from the contact 130

arms and the holder. Therefore assembly is easy and the moulding process is simplified. Also one wall of the passageway is composed of the extension of the support block 42 resulting in a small sized circuit interrupter.

Further it will be understood that the second contact arm 16 is subjected to a moment of force equal to the product of the force (f) provided by the contact springs 60, multiplied by the length (l) of the perpendicular drawn from the axis of the rotation 44 to the line of action of the contact springs 60. By proper selection of the magnitudes of the force (f) and the length (l), the contact arm is subjected to the required contact pressure. As shown in Figure 2, electromagnetic repulsion causes rotation of the second contact arm 16 to transfer the line of action of the springs 60 from line A—A¹ to B—A¹. This means that the reversing levers 46 are not subjected to the moment of force provided by the contact springs 60. Under these circumstances, the force necessary to start the reversing levers 46 is only friction around the spring pin 48. In other words, only a very small part of the electromagnetic repulsion exerted on the second contact arm 16 is necessary to rotate the reversing levers 46.

Upon the line of action of the contact springs 60 coinciding with line C—A¹, the reversing levers 46 begin to be rotated about the axis of the pin 48 in the clockwise direction to move the spring shoes 54 toward the position D¹. This causes a rapid decrease in the length of the perpendicular drawn from the axis of rotation 44 to the line of action of the springs 60. Therefore the contact pressure on the second contact arm 16 serving as a moment of rotation in the clockwise direction also rapidly decreases with the result that the second contact arm 16 is easily moved to its open position.

Accordingly, rotation of the second contact arm 16 due to the corresponding electromagnetic repulsion is accompanied by the force of the springs 60 for the levers 46 being reversely directed. This causes rotation of the reversing levers 46 to displace the spring pin 52 from the position A¹ to the position D¹. Therefore as the second contact arm 16 is rotated to pass the line of action of the contact springs 60 through line C—A¹ the force exerted in the clockwise direction on the contact arm 16 by the springs is suddenly reversed in direction with the result that the contact arm 16 is stably maintained in its open position. Thus a sufficient contact pressure is applied to the second contact arm 16 in the normal contact state and yet an electromagnetic repulsion exerted on the same arm can be effectively utilized to perform an opening operation. If position A¹ anchoring the contact

spring were fixed as in the conventional type of circuit interrupter, the force of the contact springs 60 would begin to be reversed in direction when the spring pin 56 reached a position E¹ as shown in Figure 4. Therefore, in order to ensure that such a force is reversed in direction, the second contact arm 16 must be rotated to a position E and it is difficult to reduce moment of force exerted by the springs on the contact arm. Also the angle through which the second contact arm can be rotated is required to be large. This causes an increase in depth of the housing 10 and hence in the outside dimensions thereof.

Further if the contact springs 60 have one point initially fixed at the point D¹ shown in Figure 3, the line of action coincides with the line A—D¹. This causes a decrease in the length of the perpendicular drawn from the axis of rotation 44 to the said line of action, with the result that a sufficient moment of force serving as a contact pressure on the second contact arm 16 cannot be produced. If the line of action of the contact springs 60 is desired to be reversed in direction at the position D¹ while a sufficient contact pressure is exerted on the second contact arm 16, the point where the spring 60 is anchored should extend to a position F while at the same time the spring 60 and contact arm 16 have to be increased in length. Not only does this render the contact assembly large in size, but the moment of force or the contact pressure cannot rapidly decrease after the passage through the position C¹.

Thus it will be appreciated that our circuit interrupter can be relatively small in size.

WHAT WE CLAIM IS:—

1. A circuit interrupter comprising a pair of movable contact arms disposed in substantially parallel relationship in the closed position of the interrupter, each of said contact arms being provided at one end with a contact and pivotably mounted at the other end on a pivot pin, spring means individual to each contact arm to normally apply a contact pressure to the associated contact, an operating mechanism for moving one of said movable contact arms between its closed and open positions, the said one of the contact arms being pivotably mounted to a pivotable holder connected to the operating mechanism, thermally and electromagnetically responsive trip means operatively coupled to said operating mechanism, the arrangement being such that a flow of greatly excessive current through the interrupter will generate an electromagnetic repulsion between the arms thereby to pivot at least one of the arms independently of the trip means to interrupt the current, the last-mentioned arm

arms and the holder. Therefore assembly is easy and the moulding process is simplified. Also one wall of the passageway is composed of the extension of the support block 42 resulting in a small sized circuit interrupter.

Further it will be understood that the second contact arm 16 is subjected to a moment of force equal to the product of the force (f) provided by the contact springs 60, multiplied by the length (l) of the perpendicular drawn from the axis of the rotation 44 to the line of action of the contact springs 60. By proper selection of the magnitudes of the force (f) and the length (l), the contact arm is subjected to the required contact pressure. As shown in Figure 2, electromagnetic repulsion causes rotation of the second contact arm 16 to transfer the line of action of the springs 60 from line A—A¹ to B—A¹. This means that the reversing levers 46 are not subjected to the moment of force provided by the contact springs 60. Under these circumstances, the force necessary to start the reversing levers 46 is only friction around the spring pin 48. In other words, only a very small part of the electromagnetic repulsion exerted on the second contact arm 16 is necessary to rotate the reversing levers 46.

Upon the line of action of the contact springs 60 coinciding with line C—A¹, the reversing levers 46 begin to be rotated about the axis of the pin 48 in the clockwise direction to move the spring shoes 54 toward the position D¹. This causes a rapid decrease in the length of the perpendicular drawn from the axis of rotation 44 to the line of action of the springs 60. Therefore the contact pressure on the second contact arm 16 serving as a moment of rotation in the clockwise direction also rapidly decreases with the result that the second contact arm 16 is easily moved to its open position.

Accordingly, rotation of the second contact arm 16 due to the corresponding electromagnetic repulsion is accompanied by the force of the springs 60 for the levers 46 being reversely directed. This causes rotation of the reversing levers 46 to displace the spring pin 52 from the position A¹ to the position D¹. Therefore as the second contact arm 16 is rotated to pass the line of action of the contact springs 60 through line C—A¹ the force exerted in the clockwise direction on the contact arm 16 by the springs is suddenly reversed in direction with the result that the contact arm 16 is stably maintained in its open position. Thus a sufficient contact pressure is applied to the second contact arm 16 in the normal contact state and yet an electromagnetic repulsion exerted on the same arm can be effectively utilized to perform an opening operation. If position A¹ anchoring the contact

spring were fixed as in the conventional type of circuit interrupter, the force of the contact springs 60 would begin to be reversed in direction when the spring pin 56 reached a position E¹ as shown in Figure 4. Therefore, in order to ensure that such a force is reversed in direction, the second contact arm 16 must be rotated to a position E and it is difficult to reduce moment of force exerted by the springs on the contact arm. Also the angle through which the second contact arm can be rotated is required to be large. This causes an increase in depth of the housing 10 and hence in the outside dimensions thereof.

Further if the contact springs 60 have one point initially fixed at the point D¹ shown in Figure 3, the line of action coincides with the line A—D¹. This causes a decrease in the length of the perpendicular drawn from the axis of rotation 44 to the said line of action, with the result that a sufficient moment of force serving as a contact pressure on the second contact arm 16 cannot be produced. If the line of action of the contact springs 60 is desired to be reversed in direction at the position D¹ while a sufficient contact pressure is exerted on the second contact arm 16, the point where the spring 60 is anchored should extend to a position F while at the same time the spring 60 and contact arm 16 have to be increased in length. Not only does this render the contact assembly large in size, but the moment of force or the contact pressure cannot rapidly decrease after the passage through the position C¹.

Thus it will be appreciated that our circuit interrupter can be relatively small in size.

WHAT WE CLAIM IS:—

1. A circuit interrupter comprising a pair of movable contact arms disposed in substantially parallel relationship in the closed position of the interrupter, each of said contact arms being provided at one end with a contact and pivotably mounted at the other end on a pivot pin, spring means individual to each contact arm to normally apply a contact pressure to the associated contact, an operating mechanism for moving one of said movable contact arms between its closed and open positions, the said one of the contact arms being pivotably mounted to a pivotable holder connected to the operating mechanism, thermally and electromagnetically responsive trip means operatively coupled to said operating mechanism, the arrangement being such that a flow of greatly excessive current through the interrupter will generate an electromagnetic repulsion between the arms thereby to pivot at least one of the arms independently of the trip means to interrupt the current, the last-mentioned arm



or arms when pivoted being held in the open position by reversal of the direction of the force exerted by respective associated spring means, said trip being arranged and adapted to perform a tripping operation shortly after said contact arms have separated from each other and so to cause the normal constrained state of the operating mechanism to collapse thereby automatically by pivoting of the holder by the operating mechanism, to restore to its original direction the force exerted by the spring means and thereby bring said contact arm or arms into the position resulting from normal operation of the trip means.

2. A circuit interrupter as claimed in claim 1 in which at least the arm not pivoted to the holder pivots in response to the said repulsion, said one arm being pivoted to the holder at one end of the holder and said holder being provided on that end thereof remote from the said one contact arm with an overhang and a reset element of electrically insulating material being movably disposed in spaced relationship between said overhang on said holder and the adjacent end of the other movable contact arm, collapse of the operating mechanism causing the holder to pivot to cause said overhang to strike against said reset element which engages with the adjacent end of the other contact arm thereby to return the other contact arm to its initial closed position in which it is retained by reversal of the force exerted by the associated spring.

3. A circuit interrupter as claimed in claim 2 wherein said reset element is slidably disposed within a guide passageway defined

by a support, which movably supports the other contact arm, and the adjacent tilted wall surface of a housing for the interrupter.

4. A circuit interrupter as claimed in claim 1 or 3 wherein a stop is provided to limit rotational movement of said one contact arm due to the electromagnetic repulsion, the collapse of the constrained state of said operating mechanism causing the said one contact arm to bear against the stop and to be thereby pivoted in a direction opposite the direction of rotation of the arm due to the electromagnetic repulsion thereby to cause the associated spring means to pass through its dead centre point to bring said one contact arm into its normal tripped position.

5. A circuit interrupter as claimed in any of claims 1 to 4, wherein the contact arm not pivoted to the holder includes a pivotable reversing lever provided with a pin and the associated spring means is spanned between said arm and said pin, said reversing lever being disposed so as to be moved as the other contact arm is rotated by the action of the electromagnetic repulsion and during the movement of said reversing lever said pin is displaced to effect early decrease in and reversal of a force applied to the arm by the spring means.

6. A circuit interrupter substantially as herein described and illustrated in the accompanying drawings.

MARKS & CLERK,
Chartered Patent Agents,
Agents for the Applicants.

