Aug. 26, 1969 WASABURO MURAI ET AL 3,464,038

CIRCUIT INTERRUPTER

Filed Feb. 12, 1968 2 Sheets-Sheet 1

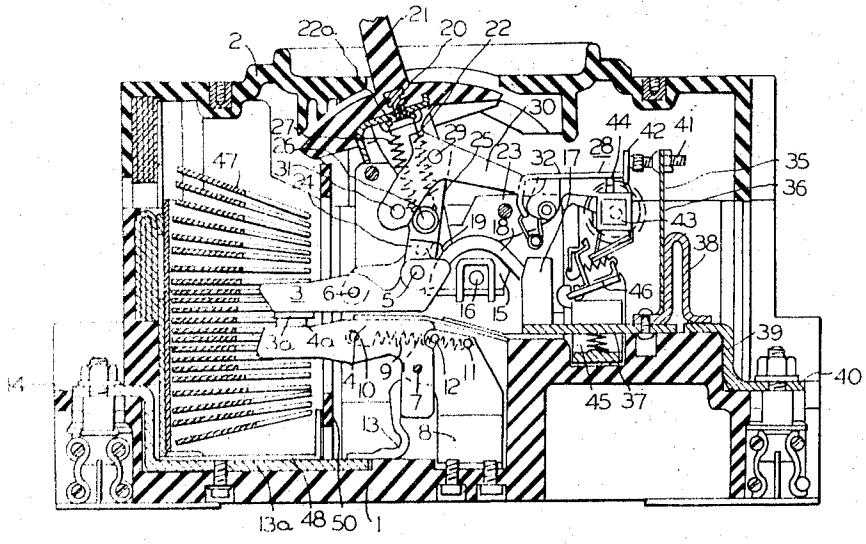

FIG.1

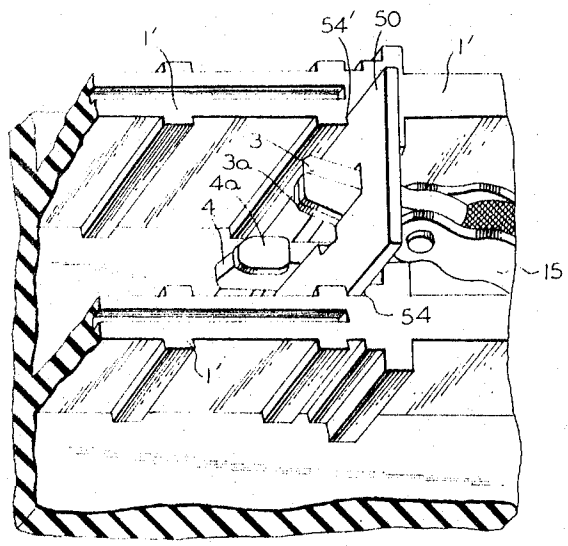

FIG.2

INVENTORS
WASABURO MURAI
YOSHIO KOBAYASHI

BY Winderoth, Sund & Vonack
ATTORNEYS

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CIRCUIT INTERRUPTER

Filed Feb. 12, 1968 2 Sheets-Sheet 2

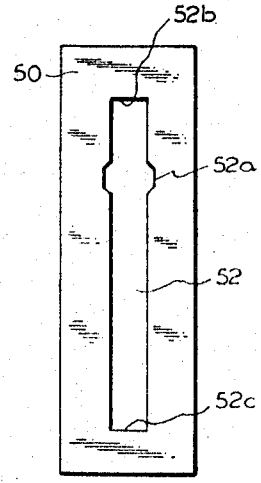

FIG.3

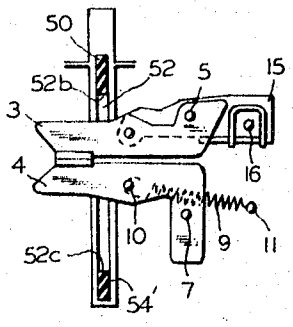

FIG.4

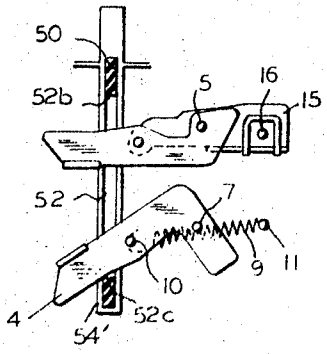

FIG.5

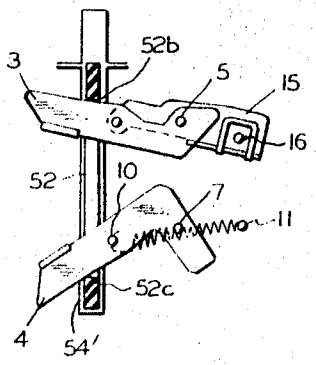

FIG.6

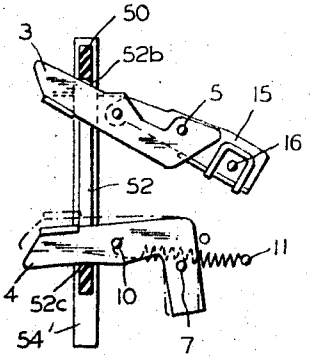

FIG.7

INVENTORS
WASABURO MURAI
YOSHIO KOBAYASHI

BY Wenderoth, Lind & Ponack

ATTORNEYS

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3,464,038

CIRCUIT INTERRUPTER

Wasaburo Murai, Osaka, and Yoshio Kobayashi, Nara, Japan, assignors to Terasaki Denki Sangyo Kabushiki Kaisha, Osaka, Japan

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Int. Cl. H01h 75/00, 77/00, 83/00
U.S. Cl. 335—16 5 Claims

ABSTRACT OF THE DISCLOSURE

A circuit interrupter comprises a pair of movable contact arms disposed in parallel relationship in their closed positions and a movable slotted coupling plate forming one side wall of an arc-extinguishing chamber. The contact arms have the respective contact bearing portions extending through a slot on the coupling plate in the arc-extinguishing chamber. Upon the occurrence of a shortcircuiting current one of the movable contact arms is moved to its open position by the action of an electromagnetic repulsion generated between both arms. A little later after this movement the associated overcurrent responsive trip device is operated to move the other contact arm to its open position. This movement is accompanied by the movement of the coupling plate to return the one contact arm to its closed position.

This invention relates to improvements in a circuit interrupter disposed in U.S. Patent No. 3,327,407, issued Oct. 5, 1966, and owned by the same assignor as the present application.

According to the cited patent, the circuit interrupter includes a pair of movable contact arms disposed in substantially parallel relationship in their closed positions and a switching mechanism coupled to one of the arms to drive it from its closed position to its open position and vice versa, the other contact arm being arranged to respond to a flow of heavy current such as shortcircuit current to be separated from the one contact arm by the action of an electromagnetic repulsion generated between both arms without any time delay while the one contact arm remains stationary by the action of the switching mechanism with the result that the associated circuit is interrupted within a very short period of time. A little later after this interruption a thermally responsive and/or electromagnetic tripping mechanism involved are or is operated to put the one contact arm in its open position. Then as the electromagnetic repulsion decrease the other contact arm returns back to its original position by the action of the associated spring resulting in the readiness for the subsequent closing operation.

An object of the invention is to provide in a circuit interrupter of the type described in the preceding paragraph, improved means for smoothly and reliably returning the other contact arm to its original closed position to be ready for the subsequent closing operation.

Another object of the invention is to increase a distance between a pair of separated contacts in a circuit interrupter of the type discribed in the preceding paragraph to shorten the interruption time of the interrupter thereby to increase the current limiting effect and accordingly its interruption capability.

Still another object of the invention is to prevent the one contact arm in a circuit interrupter of the type described in the preceding paragraph from bouncing from its open position to its closed position upon interrupting a flow of heavy current thereby to prevent re-arcing across a pair of contacts.

An additional object of the invention is to provide an improved arc-extinguishing chamber simple in construction.

Briefly, the invention accomplishes the above cited objects by the provision of a circuit interrupter comprising a pair of movable contact arms disposed in substantially parallel relationship in their closed positions, each of the contact arms being provided at one end with a contact and pivotably mounted on the other end portion on a pivot pin, an operating mechanism for switching one of the movable contact arms from its closed position to its open positions and vice versa, the other contact arm having only the contacting function and including spring means spanned between the same and a support member therefor to exert on the other contact arm a force tending to rotate the latter toward its closed position, and overcurrent responsive trip means operatively coupled to the operating mechanism, a flow of extraordinarily excessive current through the interrupter generating an electromagnetic repulsion between the pair of movable contact arms to drive the other contact arm in its open position independently of the trip means, the other contact arm being held in its open position through the reversal of the force of the spring means over the dead point thereof, characterized in that a coupling plate including a slot thereon is movably disposed so as to have the contact bearing portions of both the contact arms movably projecting beyond said slot, and that a little later after the other contact arm has been moved to its open position the overcurrent responsive trip means perform a trip operation to cause the constrained stated of the operating mechanism to collapse thereby to rotate the one contact arm to its open position while the one contact arm actuates the coupling plate to return the other contact arm back to its closed position.

Preferably, the coupling plate may be slidably disposed in opposite guide slots formed on a pair of electrically insulating partitions disposed in the interrupter.

In order to increase a distance between a pair of separated contacts, the slot on the coupling plate may be advantageously as long as possible.

The coupling plate may be conveniently disposed adjacent the contacts in their closed positions thereby to prevent the one contact arm from bouncing from its open position to its closed position upon interrupting a flow of heavy current.

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

FIGURE 1 shows partly in longitudinal section and partly in elevation a circuit interrupter constructed in accordance with the principles of the invention;

FIGURE 2 is a fragmental pictorial view of a pair of movable contact arms and a coupling plate operatively connecting both arms to each other, with a cover removed;

FIGURE 3 is a plan view of the coupling plate illustrated in FIGURE 2;

FIGURES 4 to 7 inclusive fragmental elevational views illustrating the positional relationship between the pair of contact arms and the coupling plate in the various positions of the contact arms.

While the invention will be shown and described in connection with a circuit interrupter of three pole type, it is to be understood that the same is equally applicable to circuit interrupters of single pole type and other multiple pole types. Also it is to be understood that the components common to all the poles will be illustrated and described in terms of the central pole alone.

Referring now to the drawings and FIGURE 1 in particular, there is illustrated a three pole circuit inter-

rupter constructed in accordance with the principles of the invention. The circuit interrupter illustrated comprises a housing member **1** and a detachable cover member **2**. The housing and cover members **1** and **2** respectively may be conveniently made of any suitable electrically insulating plastic by the molding technique and constitute a closed enclosure. Within the enclosure a pair of movable contact arms **3** and **4** are disposed so as to be substantially horizontally positioned in parallel relationship in the closed position of the interrupter. The contact arms **3** and **4** are made of any suitable electrically conductive material and have a pair of contacts **3***a* and **4***a* attached at their free ends respectively.

The lower contact arm **4** has the other end portion pivotably mounted on a rotatable shaft **7** by a U-shaped support member **8** for rotation about the axis of the shaft **7** and the support member **8** is rigidly secured on the bottom wall surface of the housing member **1**. Disposed on either common side of the lower contact arm **4** and the U-shaped support member **8** is a helical spring **9** having one end hooked to a pin **10** extending through the contact arm **4** and the other end secured to a pin **11** disposed on the U-shaped support member **8**. The spring **9** serves to provide to the lower contact **4***a* on the lower contact arm **4** a contact pressure under which the contact **4***a* engages the upper contact **3***a* with the pressure directed in the clockwise direction as viewed in FIGURE 1.

As will be apparent hereinafter, the lower contact arm **4** is adapted to respond to a flow of extraordinarily excessive current such a flow of shortcircuit current through the interrupter to be rotated in the counterclockwise direction as viewed in FIGURE 1. In order to prevent the lower contact arm **4** from rotating in the clockwise direction as viewed in FIGURE 1 from its closed position, a stopper **12** is disposed on the support member **8** as shown in the same figure. The lower contact arm **4** also has the other end folded and connected by way of a flexible conductor **13** to the conductor **13***a* connected to a source terminal **14**.

The upper contact arm **3** is connected by way of connecting shafts **5** and **6** to a contact holder **15** having pivotably mounted thereon a holder's shaft **16** of any suitable electrically insulating material. The holder shaft **16** is pivotably supported to the housing member **1** through a pair of opposite support members (not shown) disposed on the opposite wall surfaces of the housing member **1**. Thus the contact arm **3** is adapted to be rotatable from its closed position to its open position and vice versa about the axis of the holder shaft **16**, along with an operating mechanism for the arm as will be subsequently described. The upper contact arm **3** is also electrically connected to a connector **17** through a flexible conductor **18**.

In order to manually move the upper movable contact arm **3** from its closed position as illustrated in FIGURE 1 to its open position and vice versa, there is provided an operating mechanism generally designated by the reference numeral **20**. The operating mechanism comprises an operating handle **21** movably projecting beyond the cover member **2**, a switching lever **22** secured at one end to the operating handle **21** and pivotably mounted at the other end on a stationary pin **19** secured to a fixture block **23**, and a pair of toggle link members **24** and **25** articulated by a toggle pin **26**. The mechanism further comprises a pair of tension springs **27** spanned between a spring shoe **22***a* disposed at that end of the switching lever **22** integrally connected to the operating handle **21** and spring shoe **26***a* loosely engaging the toggle pin **26**. Thus it will be appreciated that the link members **24** and **25**, the toggle pin **26** and the springs **27** form a toggle linkage of the well known construction.

The operating mechanism **20** is operatively coupled to a trip mechanism of the conventional design generally designated by the reference numeral **28**. More specifically,

the link member **25** engages at **29** to a trip lever **30** pivotably mounted at one end on a stationary pin **31** secured to the fixture block **23** and engaging at the other end a hook **32**. Then the hook **32** is adapted to respond to a flow of overload current through the interrupter to be released,

The interrupter also comprises a thermally responsive device generally designated by the reference numeral **35** for the purpose of tripping the interrupter upon the occurrence of a flow of ordinary overload current. The thermally responsive device **35** includes a bimetal element **36** electrically connected to the connector **17** through a conductor **37**, and a U-shaped electric resistor **38** disposed adjacent the bimetallic element **36**. The resistor **38** has one end connected to the conductor **37** and the other end connected to another conductor **39** which is, in turn, connected to a load terminal **40**. As shown in FIGURE 1, an adjusting screw **41** is secured integrally at the free end of the bimetallic element **36**. Upon the occurrence of a flow of ordinary the resistor **38** and hence the bimetallic element **36** will be heated whereby the element is bent leftwardly as viewed in FIGURE 1 to push against a trip piece **42** facing the same. This causes a trip shaft **43** integral with the trip piece **42** to be rotated to disengage a catch **44** secured to the trip shaft **43** from the hook **32** resulting in a tripping operation.

If an excessive current whose magnitude may be in the order of 8 to 10 times the rating current flows through the interrupter then an electromagnet device including a stationary and a movable iron core **45** and **46** respectively is energized to perform an instantaneously tripping operation. More specifically, the stationary iron core **45** is excited with an excessive current such as above described flowing through the conductor **37** disposed adjacent the same to attract the movable iron core **46** thereby to rotate the trip shaft **43** to disengage the catch **44** from the hook **32** resulting in an instantaneously tripping operation.

As in the conventional type of three pole circuit interrupters, the housing member **1** includes a pair of electrically insulating partition walls **1'** and **1'** to divide, along with both side walls, the interior into three compartments in each of which the movable contact arms **3** and **4**, the overcurrent responsive trip devices **35**, **45**–**46**, **28**, an arc-extinguishing chamber **47** (see FIGURE 1), etc. for one pole are disposed.

According to the principles of the invention, a slotted coupling plate **50** of any suitable electrically insulating material is provided one for each pole for the purpose of effecting resetting or returning movement of the lower moved contact arm **4** attendant with a tripping or opening movement of the upper contact arm **3**. The coupling plate **50** is provided with a central longitudinal slot **52** as best shown in FIGURE 3 and slidably disposed in a pair of longitudinal guide grooves **54**, **54'** formed in opposite relationship on each pair of the opposed wall surfaces and in such positions that the contact bearing portions of both the contact arms **3** and **4** movably project beyond the slot **52** on the coupling plate **50** as best shown in FIGURE 2. The plate **50** also serves to provide one side wall of the chamber **47**.

As shown in FIGURE 3, the slot **52** on the coupling plate **50** has an enlarged portion **52***a* through which the free end portions of the contact arms **3** and **4** can be inserted into the slot, and a pair of transverse edges **52***b* and *c*. The slot **52** has a width sufficient to permit the contact bearing portions of the arms **3** and **4** to be freely moved therein and serves to bring the lower contact arm **4** from its open position to its original closed position through movement of the upper contact arm **3** from its closed position to its open position as will be described hereinafter.

If an extraordinarily excessive current such as a short-circuiting current flows through the circuit interrupter in the closed position where the upper and lower contact arms **3** and **4** respectively are in their closed positions as

shown in FIGURE 4 then such a current will flow through both contact arms disposed in parallel, in the opposite parallel directions which generates an electromagnetic repulsion between both contact arms. This electromagnetic repulsion does not affect the upper contact arm **3** because the latter is constrained by the switching or operating mechanism **20**, but it overcomes a force provided by the spring **9** to impart to the lower contact *4a* a contact pressure whereupon the lower contact arm **4** is permitted to be rotated within the slot **52** on the coupling plate **50** in the counterclockwise direction as viewed in FIGURE 4 until the line of application of the spring **9** passing through the axes of the shafts **10** and **11** is downwardly moved over the shaft **7**. This causes the force of the spring **9** to reverse in direction thereby to strike the contact arm **4** against the lower edge *52c* of the slot **52** as viewed in FIGURE 3, to depress the coupling plate **50**. At the same time, the contact arm **4** is rapidly rotated in the counterclockwise direction as viewed in FIGURES 1 and 5 until it strikes against a piece **48** of sheet vulcanized fiber disposed on the bottom of the housing member **1** (see FIGURE 1) and is held in its open position as shown in FIGURE 5 even after termination of the shortcircuiting current.

This separation of the lower contact arm **4** from the upper contact arm **3** is effective for limiting or interrupting the shortcircuiting current.

A little later after this interruption the overcurrent responsive trip mechanism is operated to cause the constrained state of the operating mechanism **20** to collapse to rotate the upper contact arm **3** in the clockwise direction as viewed in FIGURE 6 within the slot **52** on the coupling plate **50**. When the upper contact arm **3** has been rotated through a certain angle it will strike against the upper edge *52b* as viewed in FIGURE 3 of the slot **52** (see FIGURE 6) thereby to raise the coupling plate **50**. This is accompanied by lifting of the lower contact arm **4** previously engaged by the lower edge *52c* of the slot **52**. Upon the lower contact arm **4** reaching its position as shown at solid line in FIGURE 7 where the line of application of the spring **9** passes through its dead point, it will return back to its original closed position as shown at dotted line in FIGURE 7 by its own inertia.

Under these circumstances, the stopper **12** prevents the arm **4** from further rotating in the same direction. Then the interrupter can be resetted in the conventional manner to be ready for the succeeding closing operation.

The invention has several advantages. For example, upon interrupting a shortcircuiting current through the utilization of an electromagnetic repulsion generated between the upper and lower contact arms **3** and **4** the lower contact arm **4** is held in its open position through the reverseal of the force of the associated spring **9** insurring that the opening operation is performed to interrupt the associated circuit. A little later after this interruption the overcurrent responsive trip mechanism is operated to rotate the upper contact arm toward its open position. Attendant on this rotational movement of the upper contact arm **3**, the lower contact arm **4** previously put in its open position and engaging the lower edge *52c* of the slot **52** on the coupling plate **50** returns back to its original closed position to be ready for the succeeding closing operation. This eliminates the necessity of locking the lower contact arm **4** to its open position by a latch or the like with the result that the lower contact arm is smoothly driven to and held in its open position and returns back to its original closed position.

It has been found to be preferable that the length of the slot **52** on the coupling plate **50** should be chosen to be so great that during its opening movement the upper contact arm **3** strikes against the upper edge *52b* of the slot **52** to raise the lower contact arm **4** from its position where it engages the lower edge *52c* of the slot to its position where the force of the associated spring **9** reverses in direction, along with the coupling plate **50**. Thereafter the upper contact arm **3** continues to effect the opening movement to raise the coupling plate **50** and thence the lower contact arm **4** until the lower arm is stopped by the stopper **12** whereupon it reaches its closed position and simultaneously the upper arm reaches and is held in its open position.

This measure permits both contacts *3a* and *4a* to be separated from each other to such an extent that the contact arms abut against the upper and lower edges of the slot respectively leading to a longer distance by which the contact *3a* is separated from the contact *4a*.

It is well known that although only the opening movement of the lower contact arm **4** is generally effective for completing to interrupt a flow of shortcircuiting current through the interrupter that a flow of shortcircuiting current approximately corresponding to the upper limit of the interruption capability of the interrupter itself may not be completely interrupted through the completion of opening movement of the lower contact arm **4** as shown in FIGURE 5. Under these circumstances, the invention is effective for increasing a distance of separation between both contacts through an opening movement of the upper contact arm **4** effected a little later after the completion of opening movement of the lower contact arm as shown in FIGURE 6. This insures that any arc current is prevented from flowing between the separated contacts and the interruption time additionally decreases resulting in increases in both the current limiting effect and the interruption capability.

Also upon interrupting a flow of heavy current, one of movable contact arms such as the upper contact arm **3** is generally moved to its open position where it strikes against the associated stopper. This generates an impulse by which the contact arm may bounce in a direction to close it causing re-arcing or re-closing. According to the invention, however, the coupling plate **50** is disposed in the vicinity of the contacts *3a* and *4a* in their closed positions. Therefore an excessive kinetic energy of the upper contact arm **3** resulting from its opening movement is effectively spent in raising the lower contact arm **4** from its open position with the result that the upper contact arm is prevented from bouncing leading to re-arcing and/or re-closing.

In addition the coupling plate **50** of any suitable electrically insulating material constitutes one side wall of the arc-extinguishing chamber **47**. Therefore the resulting construction is not only simple but also there are provided means for effectively preventing the operating mechanism and the other components from thermally damaging due to a flow of arc current and diffusion of arced gases occurring upon interrupting an excessive current flowing through the interrupter and also shortcircuit across poles from occurring through the components.

While the invention has been illustrated and described in conjunction with a single preferred embodiment thereof it is to be understood that various changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention.

What we claim is:

1. A circuit interrupter comprising a pair of movable contact arms disposed in substantially parallel relationship in their closed positions, each of the contact arms being provided at one end with a contact and pivotably mounted on the other end portion on a pivot pin, an operating mechanism for switching one of the movable contact arms from its closed position to its open position and vice versa, the other contact arm having only the contacting function and including spring means spanned between the same and a support member therefor to exert on the other contact arm a force tending to rotate the latter toward its closed position, an overcurrent responsive trip means operatively coupled to the operating mechanism, a flow of extraordinarily excessive current through the interrupter generating an electromagnetic repulsion between the pair of

movable contact arms to drive the other contact arm in its open position independently of the trip means, the other contact arm being held in its open position through the reversal of the force of the spring means over the dead point therefor, wherein a coupling plate including a slot thereon is movably disposed so as to cause the contact bearing portions of both said contact arms to movably project beyond said slot, and that a little later after the other contact arm has been moved to its open position said overcurrent responsive trip means perform a trip operation to cause the constrained state of said operating mechanism to collapse thereby to rotate the one contact arm to its open position while the one contact arm actuates said coupling plate to return the other contact arm back to its closed position.

2. A circuit interrupter as claimed in claim 1, wherein the interrupter is of multiple pole type and said coupling plate is slidably disposed in a pair of guide grooves formed in opposite relationship on a pair of electrically insulating walls for each pole.

3. A circuit interrupter as claimed in claim 1, wherein said slot on said coupling plate has a length sufficient to raise the other contact arm from its closed position to its position where the force of said spring means reverses in direction through opening movement of the one contact arm thereby to increase a distance of separation between both said contacts.

4. A circuit interrupter as claimed in claim 1, wherein said coupling plate is disposed in the vicinity of said contacts whereby an excessive kinetic energy of the one contact arm resulting from its opening movement upon interrupting a flow of excessive overcurrent through the interrupter is spent in raising the other contact arm from its open position thereby to prevent the one contact arm from bouncing to its closed position.

5. A circuit interrupter as claimed in claim 1, wherein said coupling plate of electrically insulating material form one side wall of an arc-extinguishing chamber in which an arc-extinguishing device is disposed for each pole and said contact arms have their contact bearing portions movably projecting through said slot on said coupling slot into said arc-extinguishing chamber.

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BERNARD A. GILHEANY, Primary Examiner

H. BROOME, Assistant Examiner