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ELECTRIC CIRCUIT INTERRUPTER WITH METAL PLATES FOR ARC DIVISION HAVING V-SHAPED EDGE DIRECTED TOWARD ARC-INITIATION REGION

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FIG. 1.

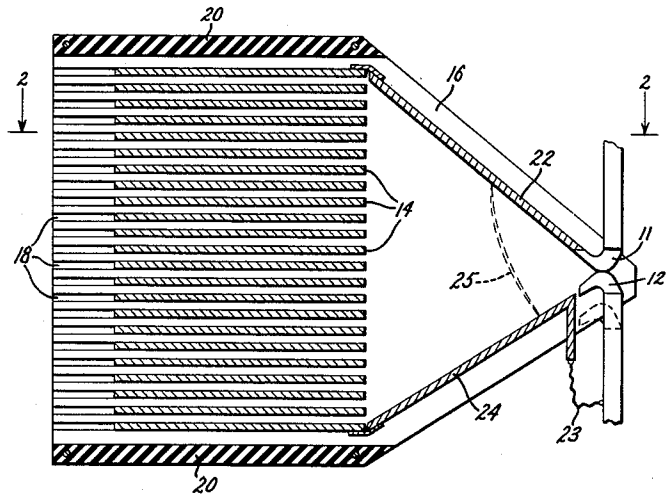



FIG. 2.

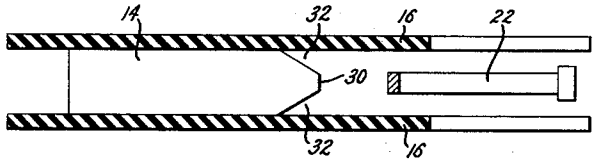



FIG. 3.

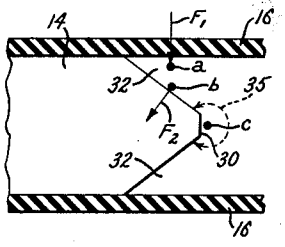



FIG. 4.

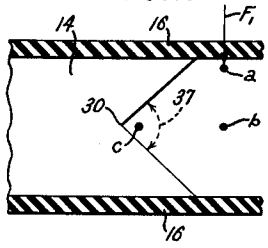
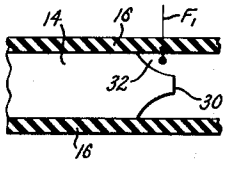



FIG. 5.




INVENTORS:
ERNEST H. BOGERT,
DONALD R. KURTZ,
VICTOR MISHKOVSKY,

BY William Freedman
ATTORNEY.

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# ELECTRIC CIRCUIT INTERRUPTER WITH METAL PLATES FOR ARC DIVISION HAVING V-SHAPED EDGE DIRECTED TOWARD ARC-INITIATION REGION

Ernest H. Bogert, Media, Donald R. Kurtz, West Chester, and Victor Mishkovsky, Philadelphia, Pa., assignors to General Electric Company, a corporation of New York

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This invention relates to an electric circuit interrupter and, more particularly, to an electric circuit interrupter of the type that comprises spaced-apart metal plates for dividing the usual arc that is drawn during interruption into a plurality of series-related arclets.

Most metal plate types of interrupters, though quite adequate for higher currents, have considerable difficulty interrupting low currents, e.g., between 50 and 400 amperes. The magnetic force that is usually relied upon to urge the arc into the plates typically varies as a direct function of the arcing current; and, as a result, under low current conditions, there is little magnetic force available to drive the arc past the forward edge of the plates. The failure of the arc to move past the forward edge of the plates greatly impairs the ability of the plates to perform their intended cooling and deionizing functions, and this delays or even prevents the desired interruption.

An object of the present invention is to facilitate entry of such low current arcs onto the metal plates.

In a preferred form of our invention the metal plates extend transversely between spaced-apart side walls of insulating material. This insulating material is of such a nature that when exposed to a low current arc for several milliseconds, sufficient gases are generated from the side walls to move the arc.

Another object of our invention is to shape the metal plates in such a manner that the above-described gases generated from the side walls by a light current arc adjacent the side walls aid entry of the arc onto the metal plates.

Still another object is to shape the metal plates in such a manner that the magnetic force pushing an arclet on to a plate once the arclet moves slightly past the forward edge of the plate increases at a more rapid rate than with prior designs.

In carrying out our invention in one form, we provide an electric circuit interrupter that contains one portion defining an arc-initiation region in which an arc is established during a circuit-interrupting operation. Extending generally parallel to the length of this arc are a pair of spaced-apart side walls of an insulating material that when exposed to an arc of less than one hundred amperes for several milliseconds emits sufficient gases to move the arc. Extending transversely of these side walls and spaced apart along the length of the arc are a plurality of metal plates, each having a forward region facing the arc-initiation region. The arc is adapted to be driven from the arc initiation region into engagement with these forward regions of the plates and is thus split into series-related arclets between the spaced-apart plates. Some of the plates contain recesses in the forward regions thereof immediately adjacent the side walls. These recesses open toward the arc-initiation region to permit entry of the arc into the recesses. If the arc should enter one of these recesses, the gases emitted from the side walls will provide a force that urges the arc toward an edge of the plate bounding the recesses.

For a better understanding of our invention, reference may be had to the following description taken in conjunction with the accompanying drawings, wherein:



FIG. 1 is a side elevational view partially in section showing an electric circuit interrupter embodying one form of our invention.

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1.

FIG. 3 is an enlarged view of a portion of FIG. 2.

FIG. 4 is a view similar to that of FIG. 3 except showing a metal plate of a type disclosed in the prior art.

FIG. 5 is a view similar to that of FIG. 3 except showing a modified form of the invention.

Referring now to FIG. 1, the electric circuit interrupter shown therein comprises a stationary contact 11 and a movable contact 12 that is movable into and out of engagement with the stationary contact. When the movable contact is driven downwardly from its solid line closed position of FIG. 1 into a dotted line open position, an electric arc is established between the two contacts 11 and 12.

For extinguishing this arc and thus interrupting the circuit, a plurality of metallic plates 14, preferably of steel extending transversely to the length of the arc are provided. These metallic plates 14 are supported in spaced-apart relationship along the length of the arc by means of a pair of laterally-spaced side wall 16 of an insulating material. These side walls 16 contain grooves 18 into which the metallic plates 14 are fitted so as to hold the plates in their illustrated position. The side walls 16 are maintained in fixed relationship to each other by means of the end plates 20 suitably secured between the side walls at the top and bottom of the interrupter. The side walls are disposed in generally parallel relationship to the length of the arc which is established between the contacts 11 and 12.

When an arc is established between the contacts 11 and 12 during an opening operation, it moves to the left along suitable arc runners 22 and 24 electrically connected to the contacts 11 and 12 respectively at the inner end of the arc runners. The electrical connection between the lower contact 12 and the lower arc runner is schematically shown at 23. A typical position through which the arc passes as it moves to the left is illustrated at 25. The principal force for driving the arc to the left is a magnetic force derived from the loop-shaped configuration of the current path through the interrupter. As is well known, the magnetic effect of such a loop-shaped path is to lengthen the loop and such lengthening is accomplished in the embodiment of FIG. 1 by movement of the arc to the left along the runners. The magnitude of this force is directly dependent upon the magnitude of the current interrupted. If desired, suitable blowout coils of a conventional character may be used to assist in moving the arc to the left.

Generally speaking, when the arc encounters the forward edge of the plates 14, it is split into a plurality of series-related arclets. These arclets move about the surface of the plates principally toward the left, and their arcing products are cooled and deionized by the plates. Assuming that the circuit is an inductive alternating current circuit, the arclets vanish at the next current zero, and the usual recovery voltage transient builds up between the contacts immediately thereafter. If the interrupter is able to recover its dielectric strength at a faster rate than the rate at which the recovery voltage transient builds up, no further arcs are established and the interruption is completed.

Most metal plate types of interrupters have considerable difficulty interrupting low current arcs, e.g., 50 to 400 amperes. In this current range, the magnetic force urging the main arc to the left along the runners 22 and 24 is relatively low and is frequently not high enough to force the arc past the forward edges of plates 14. As a result, the plates do not perform their cooling and deioniz-

ing functions to the desired extent. Accordingly, the dielectric strength of the arcing space just ahead of the plates following a current zero is not great enough to withstand the recovery voltage transient, and the arc is reignited.

As previously pointed out, an object of our invention is to facilitate entry of these low current arcs onto the plates 14. In a preferred embodiment of our invention, we have accomplished this object by (1) using for the side walls 16 an insulating material that when exposed for several milliseconds to an arc of less than 100 amperes will generate sufficient gas to move the arc and (2) shaping the forward portion of each of the plates as is best illustrated in FIG. 2. With regard to the insulating material used, examples of suitable materials are the phosphoric acid-asbestos composition described in U.S. Patent 2,366,485—Brink and Arone, or this same composition with a filler of zircon or some other inert material. The gases that are evolved from such materials when exposed to an arc are of such a character that they serve to cool and deionize the arc, as well as to move it. As for the shape of the forward portion of the plates 14, this shape may be thought of as generally V-shape with the vortex 30 of the V pointing toward the region in which the arc is initiated. Alternatively, the plate 14 may be thought of as containing recesses 32 in its forward region at opposite sides thereof immediately adjacent the side wall 16. These recesses 32 open toward the arc-initiation region and are bounded on one side by an edge of the plate 14 and on the other side by a side wall 16.

If a low current arc approaches the forward edge of a plate 14 adjacent one of the side walls 16, as is depicted at *a* in FIG. 3, the side wall will emit gases that exert a force $F_1$ on the arc tending to move the arc away from the side wall, as is indicated by the arrow $F_1$. There will also be a relatively small magnetic force $F_2$, soon to be explained, urging the arc toward the adjacent edge of plate 14. In moving away from the side wall in response to the gas force $F_1$ and the small magnetic force $F_2$, the arc approaches the edge of the plate 14, as indicated at *b*. When this occurs, the magnetic force $F_2$ increases, thus increasingly tending to pull the arc onto the steel plate 14. The forces $F_1$ and $F_2$ are in approximately the same direction relative to the edge of plate 14 and thus supplement each other to provide an exceptionally effective total force for driving the arc onto the plate 14 in the desired manner. In many cases where the force $F_2$ is not sufficient by itself to drive the low current arc on to the plate 14, the combined effect of the forces $F_1$ and $F_2$ will be sufficient.

The above-described magnetic force $F_2$ is derived from the well-known tendency of a conductor, in this case the arc, to move to a position of maximum inductance. The closer the arc comes to the edge of the steel plate, the higher will be this inductance. Thus, the magnetic force $F_2$ is in a direction to pull the arc on to the plate 14. This magnetic force $F_2$ varies as a direct function of $dL/dx$, where L is the inductance and $x$ is the travel of the arc. The inductance changes only slightly until the arc is virtually in contact with the plate 14. Thus, the force $F_2$ is only slight until this point. When the arc moves on to the plate, however, a slight movement of the arc past the edge of the plate produces a large increase in inductance, and the force $F_2$ accordingly increases relatively rapidly. This large increase in inductance results from the fact that the magnetic circuit around the rear 180 degrees of the arc periphery is changed from air to iron as the arc moves on to the plate 14 away from its edge.

Assume now that the arc in moving to the left approaches the V-shaped plate 14 at the vertex 30 of the plate, as is indicated at *c* in FIG. 3. If the arc is able to move on to the plate 14, a slight amount of movement of the arc to the left away from the edge of the plate produces an even greater value of $dL/dx$ than was described above when the arc entered from position *b*, thus producing an even greater magnetic force for driving the arc to the left away from the edge of the plate 14. This increase $dL/dx$ results from the fact that slight movement of the arc to the left away from the vertex 30 causes the magnetic circuit around an even greater portion of the arc periphery (approximately 270 degrees) to be changed from air to iron as the arc moves to the left away from the vertex 30. This peripheral region that formed the air portion of the magnetic circuit is indicated by the dotted line arrow 35.

It may be useful to compare the plate configuration of FIG. 3 with a typical prior art plate configuration such as shown in FIG. 4. In FIG. 4 there is a V-shaped notch provided in the plate 14, but the vertex 30 of this V-shaped notch points away from the arc-initiation region instead of toward it as in FIG. 3. In FIG. 4 when the low current arc approaches the plate 14 adjacent the side wall 16, the force $F_1$ produced by gases emitted from the side wall drives the arc toward the center of the arc space into a position such as *b*. But this movement is away from the edge of plate 14 instead of toward it as in FIG. 3. Thus, in FIG. 4, the force $F_1$ opposes movement of the arc on to the plate 14 rather than assisting such movement, as in FIG. 3. This opposition impedes movement of the arc on to the plates and has been found to significantly impair the ability of the interrupter to interrupt low current arcs.

If it be assumed in FIG. 4 that the arc is moving toward the vertex 30, it can be shown that for light current arcs there is a relatively small magnetic force until the arc reaches a point such as *c* closely adjacent the vertex. Since there is virtually no gas force, the total force urging the arc into the vertex is thus relatively small until the arc reaches a point such as *c*. If the arc had been urged into a position such as *b* by the gas force $F_1$, it will be apparent that there would be little force available to move the arc from *b* to *c* in FIG. 4, assuming a low current arc.

Another disadvantage of the plate configuration shown in FIG. 4 is that if the arc is able to pass on to the plate 14 at the vertex 30, there is less force urging the arc to the left away from the vertex than with the arrangement of FIG. 3. In FIG. 4 movement of the arc to the left away from the vertex 30 converts only about 90 degrees of the magnetic circuit about the arc periphery from air to iron, as compared to approximately 270 degrees in FIG. 3. Thus, $dL/dx$ is smaller in FIG. 4 during this travel and there is therefore less force for driving the arc to the left away from the vertex on the plate 14. The above-described peripheral region that formed the air portion of the magnetic circuit is indicated by the dotted line arrow 37.

Although we prefer to form all of the plates 14 of the configuration shown in FIG. 2, improved results can be obtained if less than all the plates are of the configuration of FIG. 2. It should also be apparent that minor variations in the shape of the forward portion of plate 14 can be made without departing from our invention in its broader aspects. For example, FIG. 5 shows a plate 14 with recesses 32 immediately adjacent the side wall 16 corresponding to the recesses 32 of FIG. 2, but the forward edge of the plate 14 extending from the central region to the side wall is curved instead of straight. The force $F_1$ depicted in FIG. 3 would act in substantially the same manner as in FIG. 3 to drive an arc away from the side wall 16 into engagement with the plate 14.

While we have shown and described particular embodiments of our invention, we do not wish to be limited thereto and intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A metal-plate type electric circuit interrupter comprising:

(*a*) means defining an arc-initiation region in which an elongated arc is adapted to be established during an opening operation of the interrupter;

(*b*) a pair of spaced-apart side walls of insulating material extending generally parallel to the length of said arc,

(*c*) a plurality of metal plates extending transversely of said side walls and spaced-apart along the length of said arc in insulated relationship to each other,

(*d*) each of said plates having a forward region facing said arc-initiation region and spaced therefrom against which said arc is adapted to be driven from said arc-initiation region,

(*e*) the space between said forward regions of the metal plates and said arc-initiation region being substantially free of barriers to movement of said arc into engagement with said forward regions of the metal plates,

(*f*) means for moving arcs, even low current arcs of 100 amperes or less, into engagement with the forward regions of said metal plates to divide each arc into series-related arclets between said plates,

(*g*) the forward region of at least some of said plates each having a single projecting portion located generally centrally of said side walls that projects toward said arc-initiation region to a greater extent than the portions of said plate adjacent said side walls, said portion of said plate adjacent each of said side walls defining a recess opening toward said arc-initiation region and bounded on one side by an edge of the projecting portion of said plate and on the other side by said side wall,

(*h*) the portion of said side walls located adjacent the forward region of said plates being formed of an insulating material that when exposed to an arc of less than 100 amperes peak current for several milliseconds generates sufficient gases to move the arc.



2. A metal-plate type electric circuit interrupter comprising:

(*a*) means defining an arc-initiation region in which an elongated arc is adapted to be established during an opening operation of the interrupter,

(*b*) a pair of spaced-apart side walls of insulating material extending generally parallel to the length of said arc,

(*c*) a plurality of metal plates extending transversely of said side walls and spaced-apart along the length of said arc in insulated relationship to each other,

(*d*) each of said plates having a forward region facing said arc-initiation region and spaced therefrom against which said arc is adapted to be driven from said arc-initiation region,

(*e*) the space between said forward regions of the metal plates and said arc-initiation region being substantially free of barriers to movement of said arc into engagement with said forward regions of the metal plates,

(*f*) means for moving arcs, even low current arcs of 100 amperes or less, into engagement with the forward regions of said metal plates to divide each arc into series-related arclets between said plates,

(*g*) some of said plates each comprising a single projecting portion of a generally V-shaped configuration in said forward region with the vertex of the V pointing toward said arc-initiation region,

(*h*) the portion of said side walls located adjacent the forward region of said plates being formed of an insulating material that when exposed to an arc of less than 100 amperes peak current for several milliseconds generates sufficient gases to move the arc.

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ROBERT K. SCHAEFER, *Acting Primary Examiner.*

BERNARD A. GILHEANY, *Examiner.*