Feb. 1, 1949. W. A. ATWOOD ET AL 2,460,727

ARC EXTINGUISHING DEVICE

Filed Oct. 8, 1945

Fig. 1.

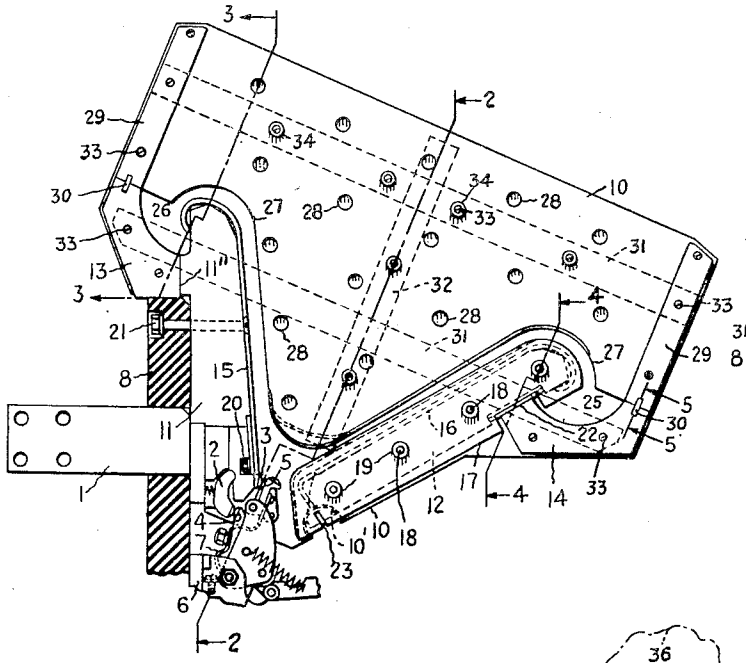


Fig. 2.

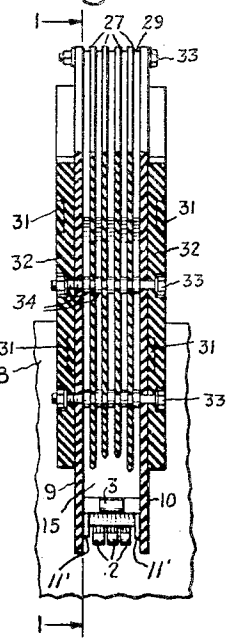


Fig. 3.

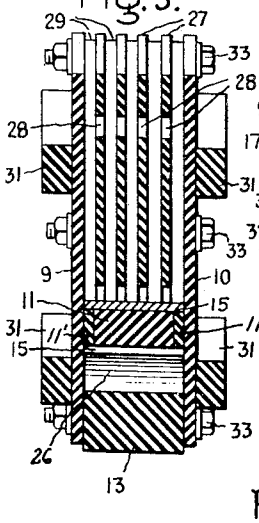


Fig. 4.

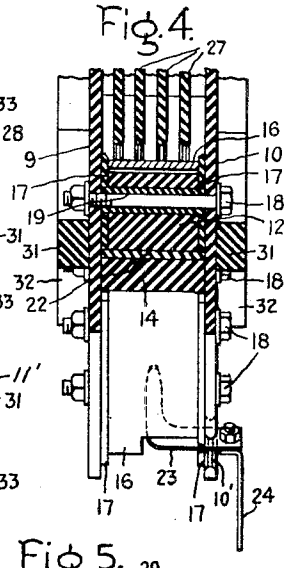


Fig. 5.

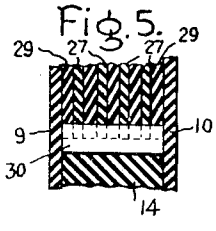


Fig. 6.

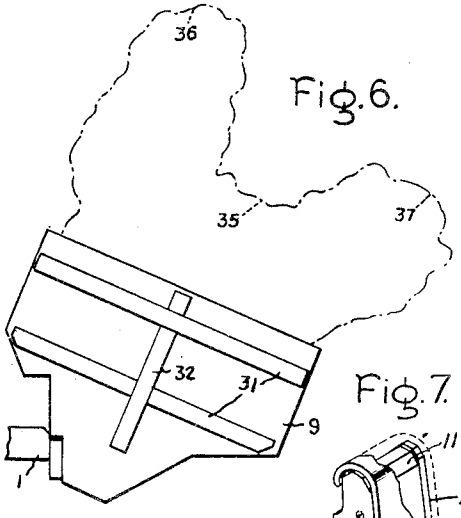
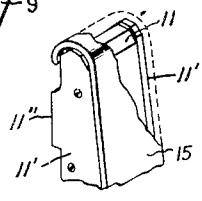


Fig. 7.



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ARC EXTINGUISHING DEVICE

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2 Claims. (Cl. 200—144)

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Our invention relates to improvements in arc extinguishing devices and more particularly to arc extinguishing devices for circuit breakers and especially circuit breakers for interrupting unidirectional currents having a high rate of rise.

Since unidirectional currents do not periodically pass through zero values as do alternating currents, the problem of circuit interruption is more difficult and especially so with so-called anode circuit breakers used in controlling arc rectifiers because of the high rate of rise of current when an arc-back occurs. Arc extinguishing devices for such circuit breakers are therefore subject to severe duty. Since vaporized metal in the arc stream tends to maintain and stabilize the arc, it is necessary to keep the metal vapor in the arc at a minimum. The metallic content of the arc stream is dependent principally upon metal derived from the arc runners. It is therefore important that the ends of the arc in contact with the arc runners be kept moving continuously in order to avoid heat concentration and the consequent high vaporizing action and also that arc runners be made of metal having a high melting temperature. Inasmuch as arcs effect a vaporizing action of the materials used in the construction of an arc extinguishing device and in consequence of the high velocities of the gases generated also effect an eroding action of the parts, such action should be controlled insofar as possible in such a way as to expedite arc extinction and to minimize the damage to the parts.

An object of our invention is to provide an improved arc extinguishing device in the form of an arc lengthening chute wherein the vaporizing action of the arc on the arc runner parts of the device is minimized and what there is of such action is so controlled as to assist in the extinction of the arc. Another object of our invention is to provide an improved arc extinguishing chute wherein the extinction of the arc is expedited by the pressure expelling action of gases confined to recidivous arcing pockets provided in the chute for oscillating the ends of the arc at the outwardly hooked ends of the arc runners.

Still another object of our invention is to provide an improved arc extinguishing chute which is readily removable from the circuit breaker and which, although compact and relatively small, has high interrupting capacity. A further object of our invention is to cool the main portion of the arc particularly while keeping the ends of

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the arc rapidly moving to the ends of the arc runners. These and other objects of our invention will appear in more detail hereinafter.

In accordance with our invention, we provide an improved arc extinguishing chute wherein divergent arc runners of high melting point electric current conducting material have their outer or discharge ends curved around into the recidivous arcing pockets formed in the arc chute to prevent the ends of the arc from becoming static and for pressure generation and intensified expelling action of the arc gases. Also in accordance with our invention, the arc runners are preferably of magnetic material in order to expedite the travel of the arc in the arc chute by the coaction of the fluxes of the arc stream and the fluxes established by the arc runners in consequence of the arc current flowing therein. Further in accordance with our invention, the arc extinguishing chute is provided with suitable arc cooling means which divide the chute into several relatively thin intercommunicating chambers.

Our invention will be better understood from the following description when considered in connection with the accompanying sheet of drawings, and its scope will be pointed out in the appended claims.

In the accompanying drawing, Fig. 1 is a side elevation of an arc extinguishing device embodying our invention with parts removed for clearness of illustration; Figs. 2, 3, 4 and 5 are sectional views on the lines 2—2, 3—3, 4—4, and 5—5, respectively, of Fig. 1; Fig. 6 is an outline diagram illustrating an actual arc discharge in a device embodying our invention; and Fig. 7 is a perspective view of a detail of the illustrated embodiment of our invention.

As shown in Fig. 1, we have illustrated an embodiment of our invention as applied to a circuit breaker such as that disclosed in Letters Patent of the United States 2,329,003, issued September 7, 1943. Since the circuit breaker itself forms no part of our invention, only such parts of the circuit breaker are shown as are pertinent to an understanding of the application of our invention.. Thus in Fig. 1, the circuit breaker is shown as including an upper terminal stud assembly 1 on which is movably supported a plurality of relatively movable main stationary contacts 2, only one of which appears in Fig. 1, and a stationary arcing contact 3. Cooperating with the main stationary contacts 2 is a movable main contact 4 and with the stationary arcing con-

tact 3 is a movable arcing contact 5. Both the movable main contact 4 and the arcing contact 5 are electrically connected to the lower terminal stud 6 of the circuit breaker by suitable means including a flexible lead 7. The circuit breaker is shown as supported on a base 8 of suitable insulating material.

In accordance with our invention, we provide an improved arc extinguishing chute which is adapted to be mounted on the circuit breaker adjacent to and principally above the arcing contacts 3 and 5. As shown, this chute comprises two spaced plates 9 and 10 of suitable insulating material for enclosing the arcs drawn between the contacts 3 and 5 upon separation thereof. In Fig. 1, the plate 9 has been removed in order more clearly to show the interior construction of our arc extinguishing chute. As shown, the outline of the plates 9 and 10 is that of a rectangle having a portion of generally trapezoidal form adjoining its lower edge. The arc chute thus has relatively large and small exhaust and arc initiating openings respectively, that is, a relatively small opening where the arc is initiated when the contacts 3 and 5 are separated at the entrance of the chute and a relatively large opening where the arc is discharged.

Between the plates 9 and 10 and along the lower front and back edges thereof, we provide insulating spacing side walls comprising as shown a series of abutting members such as blocks or diverging strips 11 and 12 of suitable insulating material and the curved side wall extension elements 13 and 14 also of suitable insulating material which together with the abutting side wall extension elements 29 form a pair of reversed J-shaped side wall extension elements abutting the diverging strips 11 and 12 behind the divergent ends thereof. In the illustrated embodiment of our invention, the insulating side wall strip members 11 and 12 are positioned between the plates 9 and 10 in an upwardly divergent relation so as suitably to support the divergent arc runners 15 and 16 thereon which constitute arcing surfaces on the strips 11 and 12, respectively. In order to eliminate gas pockets and to prevent burning of parts behind the arc runner 15 when the circuit breaker is opened while carrying current, we provide filler pieces 11' of suitable insulating material which are suitably secured to the sides of the strip 11 all as shown more clearly in Fig. 7. For protecting the side plates 9 and 10 against the eroding action of the arc terminal as it travels along the arc runner 16, protective plates 17 of high arc resistant insulating material are positioned between the plates 9 and 10 and the block 12. The arc runner mounting strip 12 is held in assembled position with the protective plates 17 and the side plates 9 and 10 by suitable fastening means such as bolts 18 which pass through suitable insulating bushings 19. The rear side wall block and arc runner support 11 is mounted on the upper stud 1 and secured thereto by suitable means such as bolts 20 and to the base 8 by bolts 21 which also assist in holding the arc runner 15 in position on the block 11. The arc runner 16 is secured to the block 12 by suitable means such as flat-headed countersunk screws, not shown. The rear side wall extension element 13 abuts a shoulder 11'' on the arc runner mounting strip 11 and the fillers 11' secured thereto and rests on the base 8 to maintain the arc extinguishing device in place and yet easily removable by lifting the device upwardly. The upwardly sloping arc runner mounting strip 12 is notched to receive the ends of the side wall extension element 14 in abutting engagement against a sealing piece of high arc resistant insulating material 22. As shown, the lower end of the arc runner 15 carries the stationary arcing contact 3. The lower end of the arc runner 16 is bent around the lower end of the arc runner mounting strip 12 and has secured thereto a terminal strap 23 to which is connected, as shown in Fig. 4, a suitable lead 24. The lower edge of the plate 10 is provided with a semi-circular notch 10' to admit the strap 23. The lower end of the lead 24 is connected to the lower stud 6 of the circuit breaker. In order to avoid confusing the drawing, this lead is not shown in Fig. 1.

In accordance with our invention, the side wall abutting members 11, 12, 13 and 14 are so shaped and arranged as to form reversely curved recidivous arcing pockets 25 and 26, shown in Fig. 1, in the arc chute for receiving the outwardly hooked ends of the arc runners 16 and 15, respectively. For this purpose, the upper edges of the side wall extension elements 13 and 14 may be curved concave upwardly and the upper or divergent ends of the spacer blocks 11 and 12 arranged to overlap the reversed hook-shaped ends of the elements 13 and 14. Further in accordance with our invention, the upper ends of the divergent arc runners 15 and 16 are outwardly curved in the form of a hook around the upper or divergent ends of the runner mounting strips 11 and 12, respectively, into the recidivous arcing pressure pockets 26 and 25, respectively. As shown, the extent of this hook curvature at the end of the arc runners is about 180°, but in general the extent of the outward curvature is governed by the inclination of the divergent arc runner to the horizontal. Stated more specifically, we find that the hook curvature should be at least sufficient to extend materially beyond the point of tangency of the arc runner with a vertical line at the end thereof. When the circuit breaker opens while carrying current of substantial magnitude the arc before breaking is forced to travel the entire length of the arc runner and the arc end or terminal is driven over the hooked end of the arc runner into the undercurving pocket nesting the end thereof. Ionized gases are thus trapped inside the pocket where they expand and are then expelled to form a low resistance path at the entrance to the pocket. In consequence of this, while other portions of the arc are being extended in length toward the breaking point, the arc terminal usually does not remain at the extreme end of the arc runner but reattaches itself to the runner above the extreme end. This action is repeated so that each time the arc thus reattaches itself, its terminal tends to be driven repeatedly along the curved portion to the extreme end of the runner and then back again thus oscillating the running end of the arc into and out of the recidivous arcing pocket to avoid the heating of individual spots with the consequent deterioration of the runner. Each time the action is repeated, gas pressure is built up in the recidivous arcing pocket nesting the end of the arc runner until the total arc length is so increased that the discharge of the arc products is effected at the top of the arc chute under the accelerating action of the built-up pressure.

In order to minimize the metallic content of the arc products and also to move the arc upwardly in the arc compartment without the use

of blowout coils and the like, the arc runners 15 and 16 are preferably made of a high melting point magnetic material such as iron or steel. Under these conditions, the reaction between the flux field of the arc and the flux fields of the runners 15 and 16 causes the arc to travel upward in the arc compartment.

In order to provide better cooling of the arc and the arc products, we provide in the arc chute between the outside plates 9 and 10 a plurality of spaced arc splitters 27 which extend downward from the top of the arc chute into the notch between the divergent arc runners 15 and 16 to varying depths, as indicated more clearly in Fig. 2. For greater cooling action and production of parallel arc paths, the arc splitters 27 are preferably perforated as indicated at 28. At the front and back edges of the arc chute, the spaces between the splitters 27 and between the splitters 27 and the plates 9 and 10 are closed by insulating side wall extension 29 which together with the reversely curved abutting elements 13 and 14 form the reversed hook-shaped side wall extensions that abut the runner mounting strips 11 and 12 behind the divergent ends thereof. In the adjoining edges of the side wall extension elements 29, the splitters 27 and the spacers 13 and 14, notches are provided for the reception of a sealing strip 30 of high arc resistant insulating material. For maintaining the rigidity and assembly of the parts of the arc chute, we provide longitudinal braces 31 and an interlocking transverse brace 32 on the outside of each of the plates 9 and 10. These braces are bolted together with the plates 9 and 10, the spacers 29 and splitters 27 by suitable means such as bolts 33. The braces 31 and 32 are preferably made of some non-frangible insulating material such as impregnated laminated wood or the like. Those bolts which pass through the splitters 27 where there are no other spacers are provided with insulating bushings 34.

Assuming the arcing contact 5 to move away from the arcing contact 3 during the opening of the circuit breaker under an overcurrent condition, for example, then an arc is formed between the contacts 3 and 5 and the end of the arc attached to the movable contact 5 is quickly transferred to the arc runner 16. Under the magnetic reaction of the flux field due to the arc and the flux fields created by arc current flow in the runners 15 and 16, the arc is caused to move rapidly upward in the chute with its ends traversing the curved portions of the arc runners 15 and 16. At the same time, by virtue of the arc splitters 27, the arc is formed into two or more parallel branches in consequence of the intercommunicating compartments between the splitters and the plates 9 and 10. These arc branches are in consequence more rapidly cooled than the whole arc from which they were derived would be cooled. With the ends of the arc on the curved portions of the arc runners and arc reformation at these points, gases are rapidly evolved in the recidivous arcing pockets 25 and 26 to build up pressures which are highly effective in blowing out or discharging the arc products at the top near the front and back of the arc chute. Thus, referring to Fig. 6 wherein the arc chute is simply outlined, the dash-dot line 35 indicates the outline of the discharged incandescent products of the arc as actually photographed during a circuit breaker interruption. From the nodes 36 and 37 of the curved outline

of the arc discharge indicated by the line 35 in Fig. 6, the expulsive action of the gases formed under pressure in the pockets 25 and 26 will be obvious. In other words, in consequence of the rapid travel of the ends of the arc into the pockets 25 and 26 where the vaporizing action is more or less highly concentrated to build up pressure quickly, the arc discharge products are violently expelled from the arc chute near the edges thereof, whereas the central or body portion of the arc is less violently expelled as will be clear by the central portion 35.

While we have shown and described our invention in considerable detail, we do not desire to be limited to the exact arrangements shown, but seek to cover in the appended claims all those modifications that 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. In an arc extinguishing device, two insulating plates forming an arc lengthening chute, insulating side walls between said plates comprising two hook-shaped elements in reverse spaced-apart alignment and two strips extending divergently outward from the arc initiating portion of the chute toward the discharge portion thereof and into abutting engagement with the inwardly curved ends of said hook-shaped elements with the ends of the strips projecting therebeyond in the chute to form therein recidivous arcing pockets open toward the discharge portion of the chute, and two divergent arc runners in said compartment respectively mounted on said strips, each of said arc runners having an outwardly hooked end curved around the projecting end of the mounting strip therefore into the recidivous arcing pocket therebehind.

2. An arc extinguishing device having in combination an arc chute provided with a pair of opposing plates having divergent side wall members mounted therebetween and each provided with a side wall extension joined behind the divergent end of the corresponding side wall member to form a recidivous arcing pocket opened towards the discharge end of the chute, and a pair of divergent arc runners of vaporizable conducting material, each mounted on the inner side of a corresponding one of the divergent side wall members and having the end of the runner hooked around the divergent end of the member into the recidivous arcing pocket for oscillating the arc into and out of the pocket and thereby minimize vaporization at the hooked end of each runner.

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