Sept. 15, 1953 D. E. WESTON 2,652,469

ARC CHUTE WITH SLOTTED AND PERFORATED BARRIER PLATES

Filed Sept. 20, 1950 2 Sheets-Sheet 1

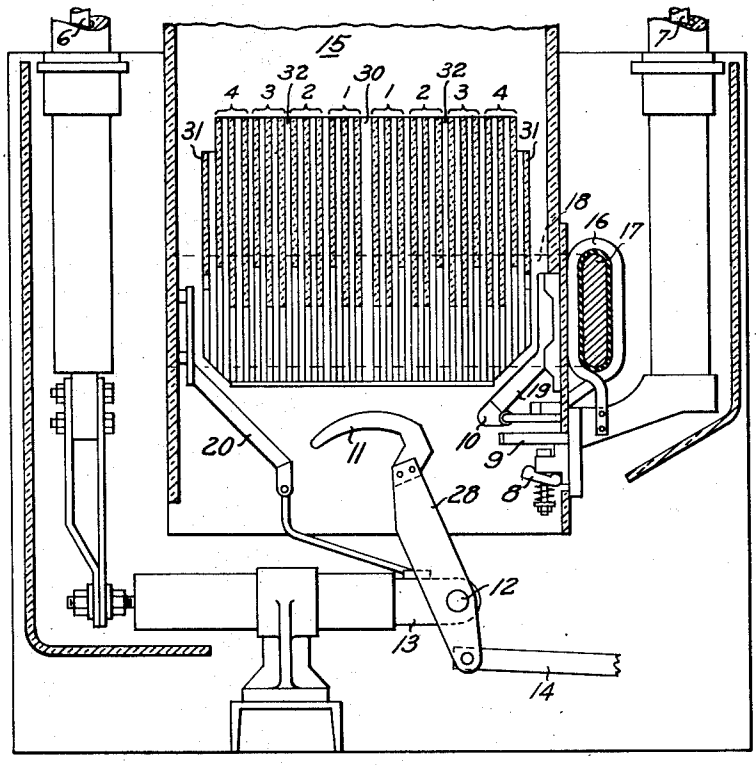


Fig. 1

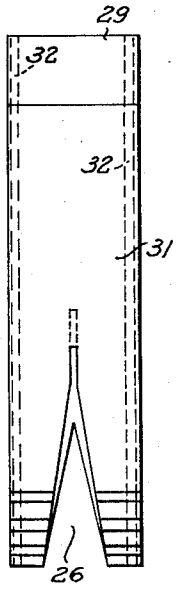


Fig. 2

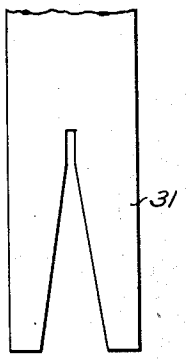


Fig. 7

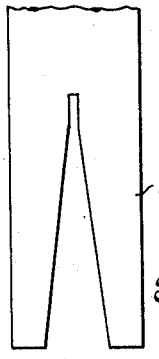


Fig. 6

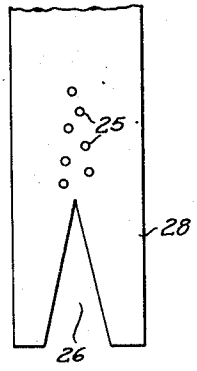


Fig. 5

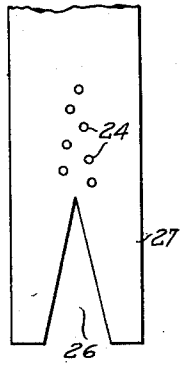


Fig. 4

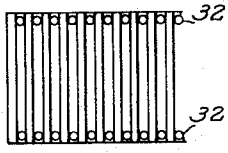


Fig. 3

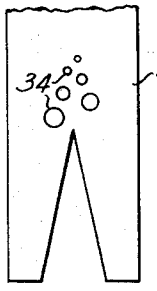


Fig. 8

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ARC CHUTE WITH SLOTTED AND PERFORATED BARRIER PLATES

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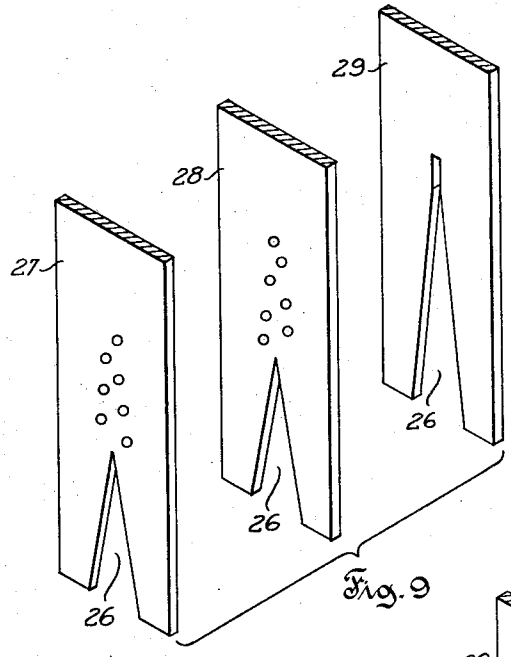


Fig. 9

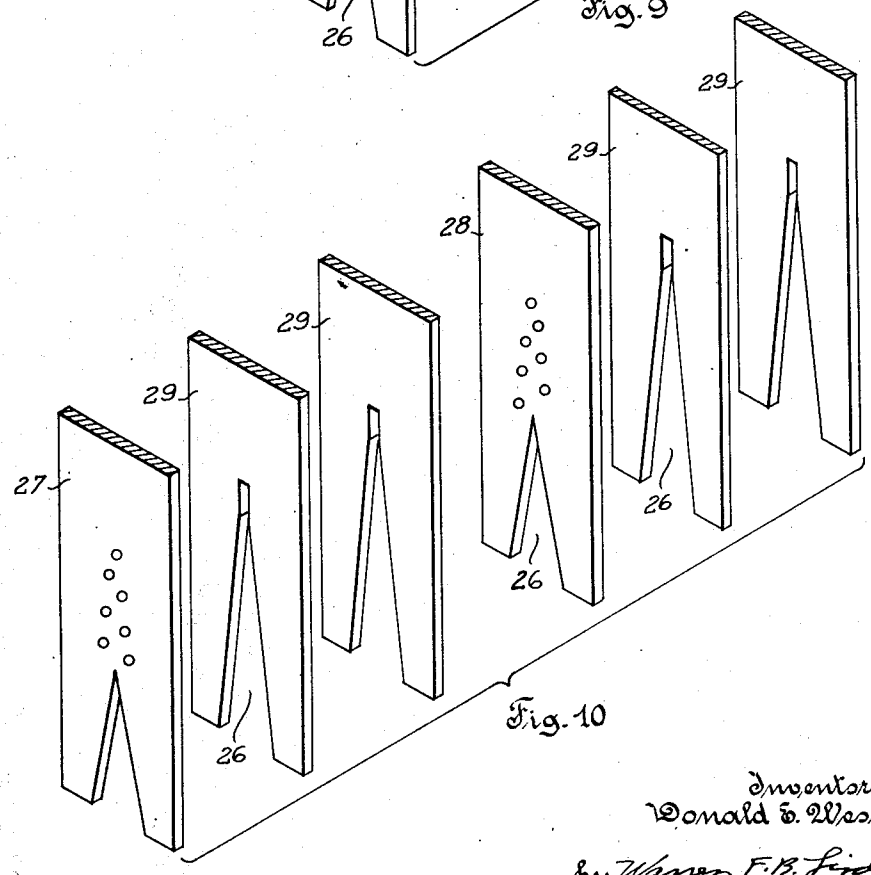


Fig. 10

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ARC CHUTE WITH SLOTTED AND PERFORATED BARRIER PLATES

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Application September 20, 1950, Serial No. 185,722

10 Claims. (Cl. 200—144)

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This invention relates to circuit interrupting devices and more particularly to arc extinguishing means for use in connection therewith.

In the construction and operation of circuit interrupters, it is frequently necessary to provide means for extinguishing quickly the arc which is drawn between separable arcing contacts. This arc is usually blown by blowout means, such as a magnetic blowout coil or an air blast, into an arc chute which is arranged to quench the arc by lengthening it, cooling it, or a combination of both.

Arc chutes having spaced insulating plates to lengthen the arc or squeeze the arc into narrow slots have been used to rapidly increase the arc voltage, decrease the arc current and greatly improve the power factor, thereby facilitating interruption of the arc at a natural or forced current zero. However, it has been found in many cases that the arc voltage developed by the arc chute was not the most favorable for interrupting the power circuit.

The geometry of the arc chute determines the arc voltage which will be developed for circuit interrupting purposes. This arc voltage can be expressed as a percentage of the line voltage and therefore is not limited to any particular voltage class of breaker. Considering an inductive circuit it may be said that a breaker in clearing the circuit may develop a minimum arc voltage following which interruption could occur, or a more desirable value following which interruption is assured. This more desirable arc voltage is the value which causes a "phase shift" during the final current loop of arcing such that the current zero of interruption occurs substantially at the same instance as voltage zero. An interruption of this nature can be referred to as interruption by means of arc voltage control. Control of the arc voltage provides complete control over the maximum arc energy that can be developed during the arcing period, control of the point on the fundamental voltage wave at which interruption will occur, control over the circuit recovery voltage characteristics, control of the magnitude of current in the loop just prior to interruption (if there is more than one loop of current during the arcing period), and control of the arcing time.

There are substantially two types of interruptions by an electromagnetic type of breaker which are acceptable and desirable. One type of interruption occurs when circuit conditions are such that the breaker interrupts the circuit at the first current zero following contact separation. For

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this type of interruption the arc chute must be designed to cause the arc to burn at a very low value of arc voltage from the instant of contact separation until the time the arc current is decreasing at or near its maximum rate of change. At this point of time the arc voltage must rise at an extremely rapid rate to a predetermined instantaneous value just prior to current zero such that the value of the recovery strength of the gap will at all times be greater than the recovery voltage of the circuit.

The second type of interruption occurs if the rate of rise of the arc voltage as the current approaches its first current zero following contact separation is not sufficiently rapid to produce the required minimum instantaneous arc voltage just prior to the current zero to obtain circuit interruption. The arc then burns for subsequent current loops at an arc voltage (preferably uniform throughout the current loop to maintain minimum arc energy) of a predetermined value to "shift the phase" such that the current zero of the interruption occurs at or near a voltage zero, thereby substantially reducing the current and the burning time of the last current loop. These two types of interruption determine low arc energy levels which greatly reduce erosion of functional parts of the circuit breakers.

Therefore, in accordance with the invention claimed an arc chute having a predetermined geometrical configuration is provided adjacent a pair of arcing contacts for receiving the arc at one end thereof and exhausting the deionized arcing products at the other end thereof. The arc chute employs an arc extinguishing device comprising a plurality of slotted spaced insulating plates arranged to extend longitudinally to the axis of the arc chute with the slots adjacent the arcing contacts to form an arc passage. A number of the plates are provided with a plurality of spaced apertures arranged adjacent the closed end of the slots of each plate for providing, for example, a zig-zag or straight line of apertures extending from the slot of each plate toward the exhaust end of the arc chute so as to define auxiliary arc passages which rapidly cool and extinguish the arc. The apertures in each perforated plate may be arranged alternatingly on the right and left sides of the axis of symmetry of the slot to restrict and first lengthen and then decrease the arc length as it moves through the arc chute.

It is, therefore, one object of the present invention to provide a new and improved arc interrupting device in which the arc may travel

through a plurality of predetermined arc paths before reaching the exhaust end of the arc chute.

Another object of this invention is to provide a new and improved arc extinguishing device in which the movement of the arc through the device is retarded by creating a high arc voltage relative to line voltage causing a rapid decrease in the arc current and consequently a rapid decrease of the motivating forces operating on the arc so that interruption occurs within a predetermined region of the arc chute regardless of the current level within the design rating of the circuit breaker.

A further object of this invention is to provide an arc chute in which the arc may, if necessary, progress through the arc chute to a relatively unheated arc path for positive or final interruption at a subsequent natural or forced current zero.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawing, in which:

Fig. 1 is a view in cross section, of a magnetic blowout type circuit breaker employing the present invention;

Fig. 2 is an enlarged end view of the stack of barrier plates of the embodiment illustrated in Fig. 1;

Fig. 3 is an enlarged partial top view of the barrier plates and barrier spacers illustrated in Figs. 1 and 2;

Figs. 4 to 7 are enlarged views of the individual barrier plates illustrated in Figs. 1 and 2;

Fig. 8 is an enlarged plan view of a modification of the barrier plate illustrated in Fig. 5;

Fig. 9 is an exploded view of one group of the stack of barrier plates illustrated in Figs. 1 to 3; and

Fig. 10 is an exploded view of a modification of the barrier plate assembly illustrated in Fig. 9.

Referring more particularly to the drawings by characters of reference, Fig. 1 illustrates a magnetic blowout type of circuit breaker including as elements thereof a pair of terminal studs **6** and **7** for connecting the circuit breaker to line conductors (not shown). Although in general, circuits breakers of the type considered in Fig. 1 are provided with a plurality of similar pole structures, one for each phase of a polyphase electric circuit, only one such pole structure is shown in the drawing and the circuit breaker will be described in detail as if it was of the single pole unit type.

The circuit interrupter or breaker in Fig. 1 comprises essentially means for opening the circuit to form the interrupting arc and an arc extinguishing structure. Specifically, the circuit opening means comprises fixed current carrying contact **8** and tertiary contact **9**, a fixed arcing contact **10**, and a movable arcing contact **11**. Arcing contact **11** is mounted on a lever **28** which is pivotally mounted at **12** on an extension **13** of the circuit breaker stud **6** and is operated by means of a reciprocally movable rod **14**. The operating rod **14** is suitably connected to an actuating mechanism (not shown) for operating the movable contact between closed and open circuit positions. Fig. 1 illustrates the movable contact **11** in an intermediate position. The arcing contacts are electrically connected to the lower ends of terminal studs **6** and **7**. Accordingly, when the breaker is connected in series in a power circuit and the arcing contacts are separated, an arm may form across the gap indicated.

For the purpose of interrupting this power arc, an arc extinguishing structure, such as an arc chute **15** may be mounted so as to receive the power arc which is under the influence of a magnetic blowout means. The arc chute preferably is disposed directly above the arcing contacts, as shown, when the blowout means act upward, but may be mounted in any other suitable location when the blowout means act in other directions. The switch or arcing contacts and the magnetic blowout structure can assume any preferred form so that a brief description thereof will be sufficient. The magnetic blowout means may comprise a core **17**, poles **18**, and a coil **16** which is electrically connected to the terminal stud **7** and to a metallic arc runner **19** so that the arc current (as the arc travels along the runner) flows through the blowout coil in a manner well known in the art.

Normally the current is carried in the closed circuit position of the breaker by contact **11** and the spring biased contact **8**. While the movable arcing contact **11** is actuated to said open circuit position, current is shunted from fixed contact **8** first to fixed contact **9** and then to fixed arcing contact **10**. As the arc is drawn by the movable arcing contact **11**, the arc terminal on arcing contact **10** is transferred to arc runner **19**, which is usually an extension arm of the fixed arcing contact **10**. While the movable arcing contact **11** approaches its full opening stroke, the other arc terminal transfers from the movable arcing contact **11** to an arc runner **20** which directs the arc into the arc chute **15**. One end of the blowout coil **16** is connected to the arcing contact **10** and the other end to tertiary contact **9**. When the movable arcing contact **11** parts from contact **9** the flow of current is transferred from contact **9** to contact **10** through the blowout coil **6**. The movable arcing contact **11** subsequently parts from contact **10** to draw an arc. Accordingly, the blowout coil is already energized at the inception of the arc interruption to influence the arc in a well known manner, i. e. to drive it into the arc chute **15** in an expanding loop. It will be apparent to one skilled in the art that the blowout field can be utilized in the most efficient manner by disposing the iron poles **18** so as to cooperate with the blowout coil in the conventional manner outside of the arc chute.

In accordance with the invention claimed, arc chute **15** is provided with a plurality of slotted spaced insulating plates arranged to extend longitudinally of the axis of arc chute **15** with the slots adjacent the arcing contacts forming an arc passage **26**. These barrier plates are arranged in a plurality of groups which restrict the arc as it moves toward the exhaust end of the arc chute. Each group may comprise a first plate **27**, (illustrated in Fig. 4) provided with a plurality of spaced apertures **24** arranged adjacent the closed end of the slot and alternatingly on the right and left sides of the axis of symmetry of the slot, a second plate **28** (illustrated in Fig. 5) which is identical to plate **27** turned around about the slot axis and therefore provided with a plurality of spaced apertures **25** arranged adjacent the closed end of the slot and alternatingly about the axis of symmetry of the slot but forming a mirror image of the apertures of the first plate **27**, and a third plate **29** (illustrated in Fig. 6) provided with only a slot of greater length than the slots in the first and second plates. A plurality of groups of barrier plates **1**, **2**, **3** and **4** are mounted to provide an

exhaust passage **30** in the center of arc chute **15** with barrier plates of the type described arranged in any suitable sequence. For example, they may be in the following sequence mounted to the right and left of passage **30** (as shown in Figs. 1 and 9): **27, 28, 29; 27, 28, 29; 27, 28, 29;** and **27, 28, 29.** The barrier plates may be mounted in any other desirable sequence and still remain within the scope of this invention. For example, the barrier plates may be mounted in groups (as shown in Fig. 10) having the following sequence: **27, 29, 29; 28, 29, 29.**

The lines of apertures in plates **27** and **28** are preferably arranged in a zigzag pattern converging toward a point near the exhaust end of the arc chute. The apertures of plate **28** being mirror images of the apertures of plate **27**, the arc is distended in both the vertical and horizontal directions as it passes through the arc chute. The vertical and horizontal distortion of the arc is greatest near the slot end of the arc chute and consequently the arc length increases as the arc passes through the apertures adjacent the slot. As the arc moves through the apertures of barrier plates **27** and **28** nearest the exhaust end of the arc chute the arc length decreases as the apertures converge toward the axis of symmetry of the barrier plate.

A barrier plate **31** of the type illustrated in Fig. 7 is provided at each end of the sequence of groups of barrier plates and adjacent the arc runners **19** and **20**. Barrier plates **31** are provided with a slot of greater length than the slots of barrier plates **27** and **28** but of lesser length than the slots of barrier plates **29**. Groups of barrier plates and individual barrier plates in each group are separated a predetermined distance from each other by suitable separators, such as, for example $\frac{3}{16}$ to $\frac{5}{16}$ inch diameter round braided asbestos rope packing **32** (as illustrated in Figs. 2 and 3). The packing is covered with a suitable coating of cement to protect it from the disintegrating effects of the arc and to unite the barrier plates into stacks of any desired number of plates. The apertures of barrier plates **27** and **28** may extend in a zigzag line from the slots of each plate toward the exhaust end of the arc chute.

Under normal interrupting conditions an arc is initiated immediately upon separation of the arcing contacts **10** and **11**. The terminal of the arc on fixed arcing contact **10** is driven over arc runner **19** by the magnetic blowout means and the thermal effect of the arc. As movable arcing contact **11** nears its fully open position the other terminal of the arc is moved from contact **11** to arc runner **20** and is also driven by the blowout means and the thermal effect of the arc toward the exhaust end of arc chute **15**.

As the arc terminals move along the arc runners **19** and **20** toward the exhaust end of arc chute **15** the arc is driven into passage **26** formed by the slots of the barrier plates.

The arc rises in passage **26** under the influence of the blowout means and the thermal effect of the arc until it is constricted at the closed slot end. The diameter of the arc section situated between the surfaces bounding the slot is relatively small while the diameter of the arc section in the space between adjacent plates is relatively large. Therefore, the arc spreads around the closed end of the slots and is cooled and deionized by the surface action of the barrier plates.

After a current zero if the arc restrikes it will occur through a path formed by the apertures nearest the slots of barrier plates **27** and **28** and that portion of passage **26** through the slots of barrier plates **29** and **31**. The arc is further restricted in diameter by the apertures of barrier plates **27** and **28** and the arc section within the apertures spreads around the holes and is cooled by the surface action of the plates.

The arc will continue its movement through the arc chute until it reaches that point in the arc chute determined by the chute's geometrical configuration where the arc current zero occurs at or near a line voltage zero. At this point the arc energy level is low and interruption occurs. Interruption at this low arc energy level greatly reduces erosion of the operating parts of the circuit breakers and lengthens its effective operating life. By providing an arc chute structure as claimed, complete control over the maximum arc energy developed during the arcing period is obtained.

By arranging the barrier plates of arc chute **15** in the sequence described, the arc chute provides a tortuous arc path which bends the arc in both the vertical and horizontal planes. The inverted V-shaped slots in the perforated plates **27** and **28** being shorter in height than the inverted V-shaped slots in the nonperforated plates has a tendency to transfer the arc from the closed ends of these slots to the perforations situated immediately above the slot ends. Hence, the arc chute provides for an easy progressing of the arc up and over the webs which separate the apertures in the barrier plates from each other but at the same time providing a predetermined number of arc paths which retards the arc a limited time so that the arc may be exposed to the cooling surface of the barrier plates a sufficient length of time.

Fig. 8 illustrates a barrier plate **33** which is a modification of barrier plate **28**. Plate **33** is provided with a plurality of apertures **34** forming a zigzag line from the slot of the plates toward the exhaust end of the arc chute. The apertures of the zigzag line gradually decrease in diameter from the slot toward the exhaust end of the arc chute.

Although but a few embodiments of the present invention have been illustrated and described it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

Features disclosed but not claimed herein are claimed in application Serial No. 217,520 of Philip L. Taylor, filed March 26, 1951, and Serial Nos. 180,258 and 209,302, filed August 18, 1950, and February 3, 1951, respectively, of Julius W. Timmerman.

It is claimed and desired to secure by Letters Patent:

1. An electric circuit interrupter comprising means for drawing an arc and an arc chute for receiving and extinguishing the arc, said chute comprising a plurality of slotted spaced insulating plates arranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage, a number of said plates provided with a plurality of spaced apertures, the apertures in any particular plate extending in a zigzag line from said slot toward the exhaust end of said chute for providing a plurality of auxiliary arc passages.

2. An electric circuit interrupter comprising means for drawing an arc and an arc chute for

receiving and extinguishing the arc, said chute comprising a plurality of slotted spaced insulating plates aranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage, a number of said plates provided with a plurality of apertures extending in a zigzag line from the slots of said plates toward the exhaust end of said chute for providing a plurality of auxiliary arc passages, said zigzag line converging to a point toward the exhaust end of said chute for gradually decreasing the arc length.

3. An electric circuit interrupter comprising means for drawing an arc and an arc chute for receiving and extinguishing the arc, said chute comprising a plurality of slotted spaced insulating plates arranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage, a number of said plates each provided with a plurally of spaced apertures, the apertures in any particular plate being arranged alternatingly on the right and the left sides of the axis of symmetry of the slot.

4. An electric circuit interrupter comprising means for drawing an arc and an arc chute for receiving and extinguishing the arc, said chute comprising a plurality of groups of slotted spaced insulating plates arranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage, at least a number of said groups comprising a first plate provided with a plurality of spaced apertures arranged alternatingly on the right and left sides of the axis of symmetry of a V-shaped slot, a second plate provided with a plurality of spaced apertures arranged alternatingly about the line of symmetry of a V-shaped slot and forming a mirror image of the apertures of said first plate, and a third plate providing only a slot of greater length than the V-shaped slots in said first and second plates.

5. An electric circuit interrupter comprising means for drawing an arc and an arc chute for receiving and extinguishing the arc, said chute comprising a plurality of groups of slotted spaced insulating plates arranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage, said groups comprising a first plate provided with a plurality of spaced apertures arranged adjacent the closed end of said slot and alternatingly on the right and left sides of the axis of symmetry of said slot, a second plate provided with a plurality of spaced apertures arranged adjacent the closed end of said slot and alternatingly about the line of symmetry of said slot and forming a mirror image of the apertures of said first plate, and a third plate providing only a slot of greater length than the slots in said first and second plates, and a plate at each end of said plurality of groups providing only a slot of greater length than said first and second plates of each group but of smaller length than said third plate of each group.

6. An electric circuit interrupter comprising means for drawing an arc and an arc chute for receiving and extinguishing the arc, said chute comprising a plurality of groups of slotted spaced insulating plates arranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage and an exhaust passage arranged to extend longitudinally of the axis of said chute substantially in the center of said chute between said groups of plates, said groups comprising a

first plate provided with a plurality of spaced apertures arranged adjacent the closed end of said slot and alternatingly on the right and left side of the axis of symmetry of said slot, a second plate provided with a plurality of spaced apertures arranged adjacent the closed end of said slot and alternatingly about the axis of symmetry of said slot and forming a mirror image of the apertures of said first plate, and a third plate providing only a slot of greater length than the slots in said first and second plates.

7. An electric circuit interrupter comprising means for drawing an arc and an arc chute for receiving and extinguishing the arc, said chute comprising a plurality of slotted spaced insulating plates arranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage, a number of said plates each provided with a plurality of spaced apertures, the apertures in any particular plate extending in a zigzag line from said slot toward the exhaust end of said chute for providing a plurality of arc passages, the sizes of said apertures gradually decreasing from said slots toward the end of said plates near the exhaust end of said chute.

8. An electric circuit interrupter comprising means for drawing an arc and an arc chute for receiving and extinguishing the arc, said chute comprising a plurality of groups of slotted spaced insulating plates arranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage, at least one of said group comprising a first plate provided with a plurality of spaced apertures arranged alternatingly on the right and left sides of the axis of symmetry of a V-shaped slot in sequence with a second and third plate provided only with a slot of greater length than the V-shaped slot in said first plate, and a second group mounted adjacent said first group comprising a fourth plate provided with a plurality of spaced apertures arranged alternatingly about the line of symmetry of a V-shaped slot and forming a mirror image of the apertures of said first plate and a fifth and sixth plate provided only with a slot of greater length than the V-shaped slot of said fourth plate.

9. An electric circuit interrupter comprising means for drawing an arc and an arc chute for receiving and extinguishing the arc, said chute comprising a plurality of slotted spaced insulating plates arranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage, each of said plates provided with a plurality of spaced apertures arranged alternatingly on the right and left sides of the axis of symmetry of the slot along a zigzag line which converges to a point toward the exhaust end of said chute, whereby said chute gradually increases the arc length during movement of the arc through a first portion of said chute and decreases the arc length during movement of the arc through a second portion of said chute.

10. An electric circuit interrupter comprising means for drawing an arc and an arc chute for receiving and extinguishing the arc, said chute comprising a plurality of slotted spaced insulating plates arranged to extend longitudinally of the axis of said chute with the slots adjacent the zone of arc initiation to form an arc passage, each of said plates provided with a plurality of spaced apertures arranged alternatingly on the

right and left sides of the axis of symmetry of the slot along a zigzag line which converges to a point toward the exhaust end of said chute, said spaced apertures arranged to first increase the arc length during movement of the arc through a first portion of said chute and thereafter decrease the arc length during movement of the arc through a second portion of said chute.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,244,061	Graves	June 3, 1942
2,276,859	Nau	Mar. 17, 1942

FOREIGN PATENTS

Number	Country	Date
403,068	Germany	Sept. 26, 1924
797,227	France	Feb. 8, 1936