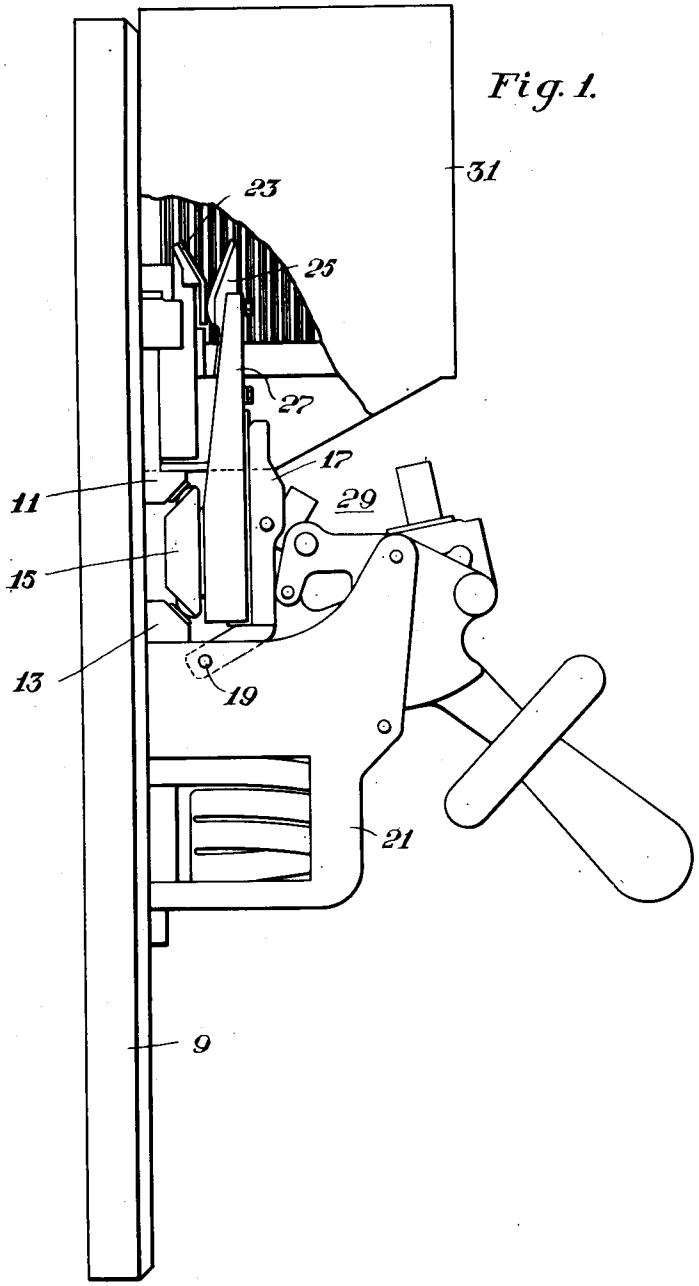
May 20, 1941. L. R. LUDWIG ET AL 2,243,039

CIRCUIT INTERRUPTER

Filed Jan. 4, 1939 3 Sheets-Sheet 1

Fig. 1.



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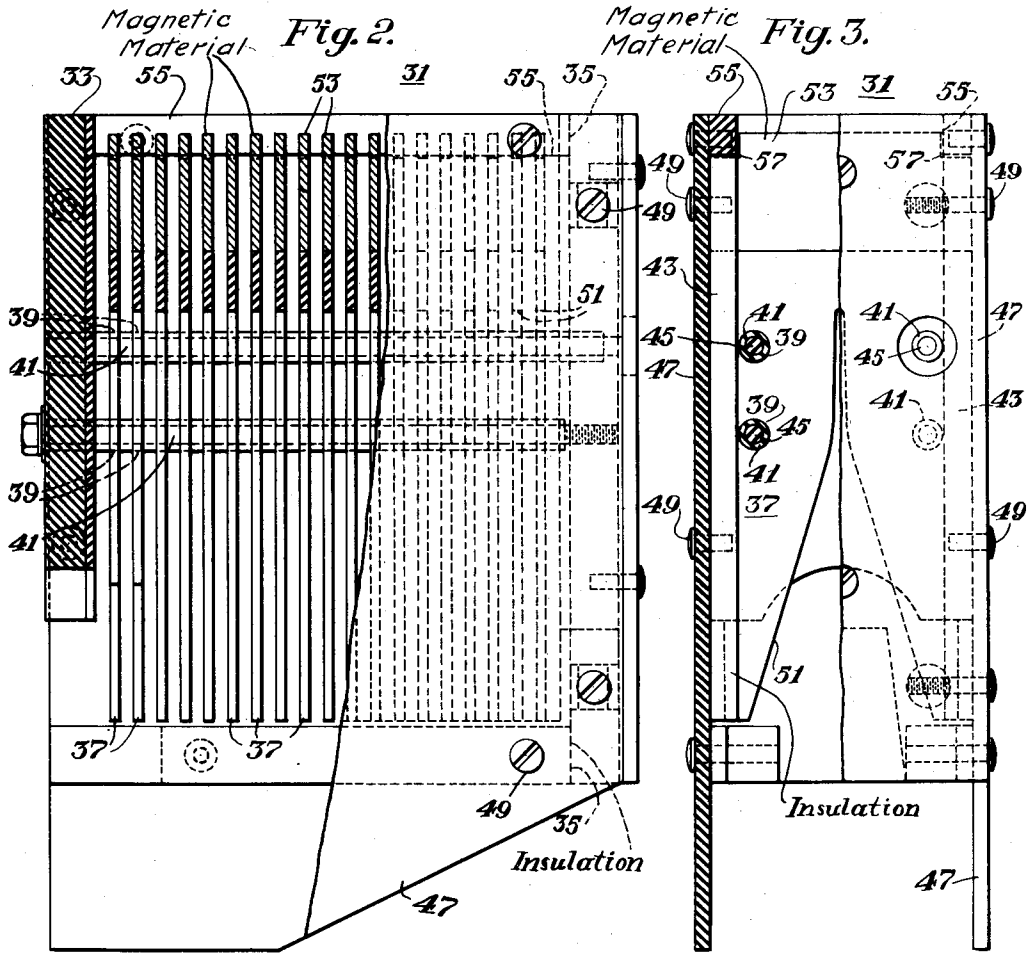
CIRCUIT INTERRUPTER

Filed Jan. 4, 1939 3 Sheets-Sheet 2



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CIRCUIT INTERRUPTER

Filed Jan. 4, 1939 3 Sheets-Sheet 3

Fig. 4.

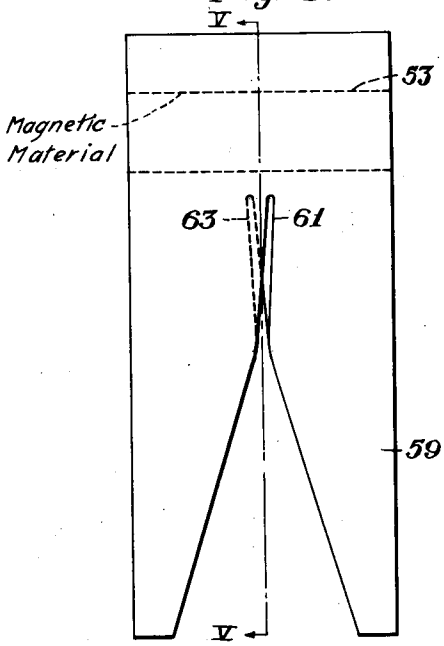


Fig. 5.

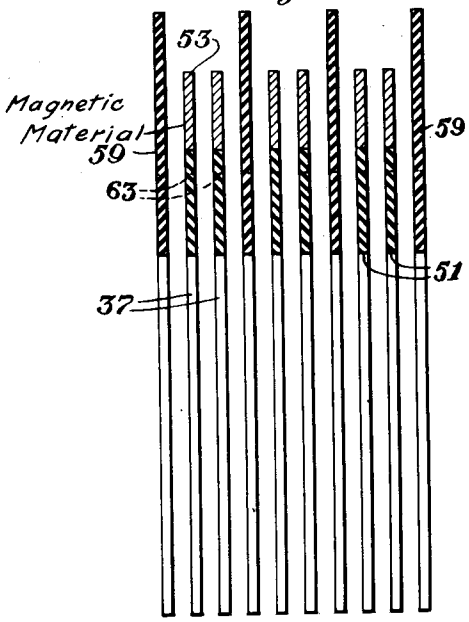


Fig. 6.

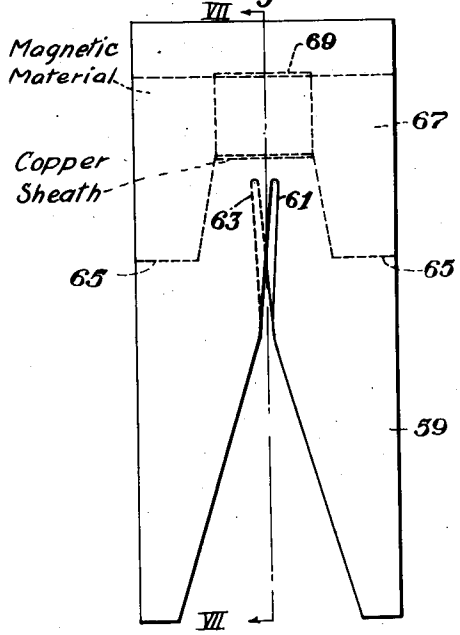
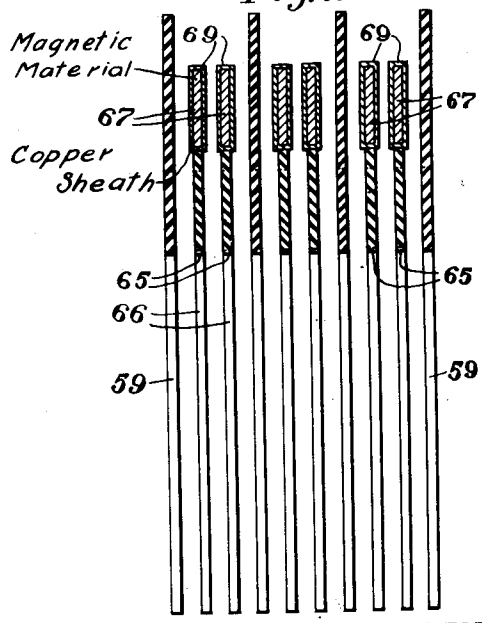


Fig. 7.



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UNITED STATES PATENT OFFICE

2,243,039

CIRCUIT INTERRUPTER

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Application January 4, 1939, Serial No. 249,210

13 Claims. (Cl. 200—147)

This invention relates to circuit interrupters and more particularly to arc extinguishing devices for circuit breakers of the air break type.

In the application of L. R. Ludwig, Serial No. 216,884, filed July 1, 1938, and assigned to the assignee of this application, there is shown and described an arc extinguishing device of the foregoing type in which arc extinction is accomplished by magnetically blowing an arc laterally into relatively narrow slots disposed in plates of insulating material. The plates of insulating material are of such width and spaced a distance apart that no material looping or bowing of the arc takes place between the plates at the closed ends of the slots, thereby causing the arc to be held in a relatively stationary position, and while being so held to be subjected to a blast of relatively cool unionized gas produced by the same magnetic action which initially caused arc movement to the end of the slots.

The instant invention has for its object the provision of improvements in an arc extinguishing structure of the type described in the aforesaid application, whereby more efficient and effective arc movement and gas blasts are obtained.

Another object of our invention is the provision of an arc extinguishing structure of the aforesaid type in which the magnetic field producing means is disposed with respect to the plates of insulating material in a manner to materially increase the voltage rating of the device.

A more specific object of the invention is the provision of a magnetic field producing structure for arc extinguishing devices of the air break type, whereby arc extinction is facilitated during the interruption of alternating-current circuits by maintaining the arc under the influence of an effective magnetic field during the time the arc current passes through zero in its cyclic wave.

A further object of the invention resides in the provision of improvements in an arc extinguishing device of the aforesaid type directed to decreasing the rate of deterioration of the arc extinguishing plates by the action of the arc thereon.

Additional objects and advantages will appear hereinafter in the specific description of the structural embodiments of our invention as shown in the accompanying drawings, in which:

Figure 1 is a side elevation view of the circuit interrupter of our invention showing a portion of the arc extinguishing device broken away to reveal the position of the arc drawing contacts with respect to the arc extinguishing plates;

Fig. 2 is an enlarged side elevation view, partially in section, of the arc extinguishing device of our invention;

Fig. 3 is an end elevation view, partially in section, of the arc extinguishing device of Fig. 2;

Fig. 4 is an end elevation view of a modified form of plate structure which may be used in our arc extinguishing device;

Fig. 5 is a fragmentary sectional view of the plate structure shown in Fig. 4, taken along the line V—V thereof;

Fig. 6 is an end elevation view of another form of plate structure which may be used in our arc extinguishing device; and

Fig. 7 is a fragmentary sectional view of the plate structure shown in Fig. 6, taken along the line VII—VII thereof.

In Figure 1 of the drawings, the reference numeral 9 designates a panel upon which a pair of stationary main contacts 11 and 13 are mounted in spaced relation. The main contacts 11 and 13 are bridged by a contact member 15 operatively carried by a movable operating arm 17 pivoted at its lower end at 19 to a supporting frame 21 also mounted upon the panel 9. A stationary arcing contact 23 is connected to the stationary main contact 11 and cooperates with a movable arcing contact 25 carried by the contact arm 27, which is also associated with the operating arm 17. The operating arm 17 is associated with an operating mechanism generally indicated at 29 for actuating the bridging contact 15 and the arcing contact 25 to the open circuit position. Inasmuch as the specific contact arrangement and the operating mechanism therefor is not specifically claimed in the instant application, further details relating to the construction thereof may be obtained by referring to the application of M. E. Horn, Serial No. 216,708, filed June 30, 1938, now Patent No. 2,214,471 dated September 10, 1940, and also assigned to the assignee of the instant application.

When the contacts 23 and 25 separate under load, an arc established therebetween is adapted to be extinguished by an arc extinguishing device 31 shown in detail in Figs. 2 and 3. The arc extinguishing device 31 comprises a back support plate 33 and a front support plate 35, each of insulating material, between which are disposed a plurality of plates 37 of insulating material. The plates 37 are provided with four apertures 39 to facilitate the assembly thereof upon an equal number of insulating tubular rods 41. The plates 37 are spaced from each other by insulating spacing members 43 disposed along opposite

side edges of the plates. Bolt **45** passing through the two lower tubular rods **41** and also through the front and back support plates **33** and **35** clamp the plate assembly in the assembled position. The two upper tubular rods **41** of insulating material provide through passages to the panel **9** for bolts (not shown) for securing the arc extinguishing device to the panel **9**. The insulating spacing members **43** are held in alignment along their inner edges by the tubular rods **41**, and along their outer edges by cover plates **47** secured to the front and back support plates **33** and **35** by screws **49**, as more clearly shown in Fig. 3.

Each of the plates of insulating material **37** is provided with a V-shaped slot **51** extending inwardly from the lower end thereof, and preferably has a configuration as more clearly shown in Fig. 3. Disposed above and in abutting relation with each plate **37** is a plate **53** of magnetic material such as iron, which is maintained between the spacing strips **43**, and is preferably of the same thickness as the plates **37** so as to form a continuation thereof. In order to prevent displacement of the plates **53** of magnetic material upwardly, a pair of longitudinally extending bar members **55** secured along the upper edge of each side plate **47** are provided which register with rectangular detents **57** formed in the upper corners of the plates **53**.

The operation of the device is as follows: Upon the separation of arcing contacts **23** and **25** within the enlarged lower portions of the slots **51**, an arc is established which immediately moves upwardly into the narrower portions of the slots **51** as a result of the inherent magnetic reaction combined with the normal thermal effect produced by the arc. In addition to the inherent tendency for movement of the arc upwardly, the plates of magnetic material **53** are positioned only adjacent the restricted end of the slots **51** so as to have set up therein a magnetic reaction due to the arc current to create a magnetic field which increases in intensity as the arc is moved towards the plates **53** and further assists in the movement of the arc. This magnetic reaction is sufficient to force the arc into the restricted narrow slot-like portions wherein arc extinction takes place.

In accordance with the theory fully set forth in the aforesaid application of L. R. Ludwig, Serial No. 216,884, the arc upon reaching the closed ends of the slots **51** is, due to the particular spacing of the plates **37** and the thickness of these plates, as well as the strength of the magnetic field acting thereon, prevented from looping or bowing a substantial distance between the plates. While the arc is thus maintained at the apex of the slots **51**, the spaces between the plates determined by the spacing members **43** permits ionized gas particles to freely escape upwardly. Movement of these ionized particles from out of the arc stream is accelerated by the action of the magnetic field. Unionized gas particles are, therefore, continually moved into and through the arc stream which must become ionized if the arc is to be maintained. However, this action of moving the relatively unionized gas particles into the arc stream materially raises the arc voltage. Thus the magnetic field creates a gas blast through the arc which in a very short interval of time raises the arc voltage to such a degree that the arc can no longer be maintained and arc extinction takes place.

More effective arc extinction is obtained when the plates are constructed of refractory materials or materials which evolve substantially no gas when acted upon by an arc, such as asbestos-board, quartz, soapstone or titanium oxide. Cold molded compositions, as, for instance, a product known as artificial porcelain comprising 30% talc, 2% feldspar, and 68% clay, are also suitable. In general, all materials which are refractory in nature and have the requisite mechanical strength are suitable for this purpose.

It has also been found that more efficient arc extinction is obtained when the plates **37** of insulating material are from ⅛ to ¼ inch in thickness and spaced from each other from ⅛ to ¼ inch. It is also of importance that the slots **51** in each of the plates **37** have a given configuration. For example, the slot that varies in width from $\frac{1}{16}$ inch at its apex to ⅛ inch at a point two inches removed therefrom has substantially the proper taper at its upper or narrower end. The lower portion of the slot, however, may increase in width more rapidly, and as long as the sides have a smooth contour and are of sufficient width to permit the moving contact **25** to pass therethrough, no difficulty is experienced in obtaining the requisite arc movement.

We have also found that it is desirable to extend the narrow portion of the slots **51** to within approximately 3/16 inch of the magnetic plates **53**. Although this particular distance is preferred, it is not critical, in that satisfactory operation has also been obtained by shortening the distance between the ends of the slots **51** and the plates **53** of magnetic material even though the corrosive effect of the hot arc gases upon the metal plates **53** was more pronounced. Although positioning of the plates **53** a greater distance from the apex of the slots **51** decreases the corroding effect upon the plates **53**, the magnetic reaction set up in the plates for moving the arc into the slots becomes less effective.

By using spacing members **43** of insulating material between adjacent plates **37** it has been made possible to utilize a plate **53** of magnetic material across the upper end of each plate **51** of insulating material, thereby greatly increasing the number of plates of magnetic material and consequently materially strengthening the magnetic field for arc movement and for the creation of a gas blast. The use of magnetic plates, as shown and described in the aforesaid application of L. R. Ludwig, for spacing the plates **37** of insulating material from each other would require the alternate use of plates of insulating material extending between the cross plates of magnetic material, in order to secure the requisite overall insulation of the arc extinguishing device. The arc extinguishing device shown in Figs 2 and 3 is capable of interrupting arcs of at least 250 volts per inch arc length on direct current, and at least 350 volts per inch arc length on alternating current. More specifically an arc extinguishing device as herein shown having an effective arc length of 6 inches has successfully interrupted 20,000 amperes at 2500 volts alternating current.

In order to increase the interrupting voltage so as to adapt the device for operation in a higher voltage circuit, it is desirable to provide a plate structure as shown in Figs. 4 and 5. As shown in these figures, an occasional plate **37** of the foregoing structure has been omitted and a longer plate **59** substituted therefor. The plates **59** extend beyond the upper end of the plates **53** of magnetic material and, therefore,

sectionalize certain groups of magnetic plates so as to increase the breakdown voltage along the entire stack of plates.

Improved operation may also be obtained and the voltage per inch arc length interrupted may also be increased by staggering the upper or extremely narrow portion of the slots in the plates 57 and 59, as more clearly shown in Fig. 4, at 61 and 63. We have discovered that a displacement of the upper end of the slots laterally from the central vertical axis of the slot from 1/16 inch to 1/8 inch is a preferred arrangement. The effect of staggering the slots in the plates, as shown in Fig. 4, is to cause a more rapid rise in the arc voltage, which in turn causes an arc which has moved to the end of the slot to momentarily be extinguished and restrike at a lower point along the narrow portion of the slot, thus an oscillating effect is obtained which materially decreases the burning effect of the arc along the narrow portion of the slot.

We have also discovered that improved operation may be obtained by the provision of a plate structure, as more particularly shown in Figs. 6 and 7. In this instance, the plates 59 are the same as previously described, whereas the shorter plates designated as 66 have a trapezoidal section 65 removed from each upper corner, as more clearly shown in Fig. 6. This permits the use of a U-shaped magnetic plate 67 to be employed in which the opposed legs extend into the cutout sections 65 of the plates 66. The leg portions of the plates 67, however, extend only a short distance along the sides of slots 61 and 63 and flare outwardly so as to produce a magnetic field which increases in intensity as the arc approaches the closed ends of the slots. The transverse or yoke portions on the magnetic plates 67 are covered with a sheath of conducting material 69, such as copper or the like. The purpose of the sheath 69 is two-fold. First, it protects the magnetic plates 67 from the direct attack by the hot arc gases passing through the venting spaces between the plates and, therefore, permits positioning the plates of magnetic material 67 closer to the apex of the slots, with the resulting increase in the magnetic action for bringing about arc extinction. Secondly, the copper sheath 69 forms a short-circuited connection about the yoke of each plate 67 so as to bring about a phase shift in the flux produced in the plate by the arc current, so that during the interruption of alternating current a substantial magnetic field will be maintained at current zero. This is of particular importance in bringing about arc extinction at the most propitious time in the current wave; that is, when the current is passing through the zero region of the wave.

From the foregoing description it will be apparent that the modifications in plate structures shown in Figs. 4 and 5, and 6 and 7, either with aligned or staggered slot constructions, may be substituted for the particular plate structure shown in Figs. 2 and 3. It is also to be understood that the use of a staggered slot arrangement as shown in Figs. 4 and 6 in the particular plate structure shown in Figs. 2 and 3 is within the teachings of the present invention.

Although we have shown and described a specific circuit interrupter and an arc extinguishing device or devices therefor, it is to be understood that the same is for the purpose of illustration, and that changes and modifications may be made by those skilled in the art without departing from the spirit and scope of the appended claims.

We claim as our invention:

1. In a circuit interrupter, an arc extinguishing device comprising a plurality of plates of insulating material, means spacing said plates from each other, each of said plates having a tapered notch extending inwardly from one end thereof, said notches forming a groove in which an arc is adapted to play, means for establishing an arc along said groove, and a plate of magnetic material for each of a plurality of said plates of insulating material disposed in abutting relation edgewise across the end thereof adjacent the closed end of said notch, said plates of magnetic material setting up a magnetic reaction for moving the arc towards the closed end of said notches and causing a blast of gas to pass laterally through the arc, said plates of magnetic material extending only across the ends of said plates of insulating material at the closed ends of said notches so that said magnetic reaction set up by said magnetic plates increased in intensity with movement of the arc towards the closed ends of said notches.

2. In a circuit interrupter, an arc extinguishing device comprising a plurality of plates of insulating material, each of said plates having a slot extending inwardly from one end to substantially the other end thereof, said plates being arranged in spaced relation with respect to each other and with the open ends of said slots in alignment and with the closed ends of said slots in staggered relation, means for establishing an arc within the aligned open ends of said slots, and a plate of magnetic material for each of a plurality of said plates of insulating material disposed in abutting relation edgewise across the end thereof adjacent the closed end of said slot, said plates of magnetic material setting up a magnetic reaction for moving the arc towards the closed ends of said slots and causing a blast of gas to pass laterally through the arc, said plates of magnetic material extending only across the ends of said plates of insulating material at the closed ends of said slots so that said magnetic reaction set up by said magnetic plates increases in intensity with movement of the arc towards the closed ends of said slots.

3. In a circuit interrupter, an arc-extinguishing device comprising a plurality of plates of insulating material, means of insulating material disposed between each of said plates along the opposed side edges thereof, each of said plates having a tapered slot extending inwardly from one end to substantially the other end thereof, means for establishing an arc in the open ends of said slots, and a plurality of plates of magnetic material disposed in alignment with said plates of insulating material and only across the ends thereof adjacent the closed end of said slots for moving the arc laterally towards the closed ends of said slots, said plates of magnetic material setting up a magnetic field across said slots for moving the arc, which field increases in intensity in accordance with movement of the arc towards the closed ends of said slots, the thickness of said plates of insulating material, the spacing thereof and the dimensions of said slots being so proportioned that arcs of at least 250 volts per inch of arc length are extinguished by said device.

4. In a circuit interrupter, an arc extinguishing device comprising a plurality of plates of insulating material, means spacing said plates

from each other, each of said plates having a slot extending inwardly from one end thereof, said slots having an entrance portion which decreases in width rapidly from the open ends thereof for a substantial distance along the longitudinal axis of the slots and a narrower remaining portion which decreases in width at a slower rate, means for establishing an arc in said entrance portion of said slots, and means of magnetic material for biasing said arc laterally towards the closed ends of said slots, said means of magnetic material being so arranged with respect to the ends of said slots that the biasing force produced by said means of magnetic material increases in magnitude in accordance with movement of said arc towards the closed ends of said slots, said plates being arranged with the entrance portions of said slots in alignment and with the remaining narrow portions of said slots in staggered relation to cause said arc to oscillate longitudinally of said narrow slot portions.

5. In a circuit interrupter, an arc extinguishing device comprising a stack of plates of insulating material arranged in spaced relation to provide venting spaces between adjacent plates, each of said plates having a tapered arc receiving slot of uniform length extending inwardly from one end thereof, means for establishing an arc in said slots, said slots in alternate plates having at least a portion adjacent their closed ends displaced laterally with respect to each other to provide a zig-zag path for said arc, certain of said plates being of greater length than the remaining plates, and a plate of magnetic material disposed in abutting endwise relation with each of the shorter plates of insulating material for biasing the arc laterally toward the closed ends of said slots, said plates of magnetic material being so arranged with respect to said slots that the biasing force produced by said plates increases in magnitude as the arc moves towards the closed ends of said slots, the longer of said plates of insulating material being disposed at spaced intervals along the stack of plates and having a length at least equal to the combined length of said shorter plates and said plates of magnetic material to prevent the formation of an arc across said plates of magnetic material.

6. In a circuit breaker for interrupting an alternating current circuit, an arc extinguishing device comprising a plurality of plates of insulating material, a slot in each of said plates extending inwardly from one end thereof, means for establishing an arc in said slots, a plurality of plates of magnetic material disposed across the ends of said plates of insulating material adjacent the closed ends of said slots, said plates of magnetic material being so arranged with respect to said slots that in the presence of said arc a magnetic field is set up for moving the arc towards the closed ends of said slots which field increases in intensity as the arc is moved toward the closed ends of said slots, and means associated with said plates of magnetic material for shifting the phase relation between said magnetic field and the arc current to cause a substantial field to persist at current zero.

7. In a circuit breaker for interrupting an alternating current circuit, an arc extinguishing device comprising a plurality of plates of insulating material, a slot in each of said plates extending inwardly from one end thereof, means for establishing an arc in said slots, U shaped plates of magnetic material having opposed leg portions joined by a transverse yoke and disposed to form extensions of at least a plurality of said plates of insulating material and arranged with said leg portions on opposite sides of a slot in a plate of insulating material, said plates of magnetic material in the presence of said arc causing a magnetic field for moving the arc toward the closed ends of said slots, and a short-circuited conductor about the yoke of each plate of magnetic material for causing said magnetic field to be maintained through current zero.

8. In a circuit breaker for interrupting an alternating current circuit, an arc extinguishing device comprising a plurality of plates of insulating material, a slot in each of said plates extending inwardly from one end thereof, means for establishing an arc in said slots, means spacing said plates from each other to provide venting passages therebetween, U shaped plates of magnetic material having opposed leg portions joined by a transverse yoke and disposed to form extensions of at least a plurality of said plates of insulating material and arranged with said leg portions on opposite sides of a slot in a plate of insulating material, said plates of magnetic material in the presence of said arc causing a magnetic field for moving the arc toward the closed ends of said slots and a blast of gas laterally through said arc, and a short circuited sheath of copper about the yoke of each plate of magnetic material for causing said magnetic field to be maintained through current zero and for preventing the hot arc gases from impinging upon said yokes.

9. In a circuit interrupter of the air break type, an arc-extinguishing device comprising a plurality of spaced plates, each of said plates having a notch therein in which an arc is adapted to play, means for establishing an arc in said notches, means of magnetic material adjacent one end of said notches for establishing a magnetic field across said end of the notches for moving the arc toward said end, and said means of magnetic material extending no more than a small distance toward the other end of said notches.

10. In a circuit interrupter of the air break type, an arc-extinguishing device comprising means of insulating material having a notch therein in which an arc is adapted to play, said means of insulating material having vent passages extending therethrough from one end of said notch to the outside thereof, means for establishing an arc in said notch, means of magnetic material positioned at said end of the notch for moving the arc toward said end of the notch and for causing a flow of gas from said notch through the arc and out said vent passages, and said means of magnetic material being positioned only adjacent said end of the notch.

11. In a circuit interrupter, an arc extinguishing device comprising a plurality of spaced plates of non-gas forming insulating material, said plates having substantially aligned tapered slots extending inwardly from one of their ends, means for establishing an arc within the larger portion of said slots, said slots terminating in constricted tips which progressively decrease in width to the closed end thereof and which have a width at their entrance portion to preclude alternating current arcs above a predetermined instantaneous current magnitude from entering therein, and magnetic means disposed only adjacent to the closed ends of said slots for moving said arc

laterally within said slots and into said constricted tips following decay of the instantaneous current below said predetermined magnitude, said magnetic means exerting a progressively greater force upon said arc as it moves towards the closed ends of said slots.

12. In a circuit interrupter, an arc extinguishing device comprising a stack of plates of insulating material, means spacing said plates a predetermined distance from each other to provide vent passages through the stack, said plates having elongated tapered notches therein which terminate in a constricted tip decreasing progressively in width from no greater than ⅛" at a point at least 2" from the closed end of the notches to no greater than 1/16" at the closed end, means for establishing an arc within said notches, and plates of magnetic material disposed only adjacent to the closed ends of said notches to provide a magnetic field for moving said arc into said constricted tips which field increases in intensity as the arc moves towards the closed ends of said notches.

13. In a circuit interrupter, an arc extinguishing device comprising a stack of plates of insulating material, means spacing said plates a predetermined distance from each other to provide venting passages, said plates being substantially free from materials which give off gas when acted upon by an arc and having elongated tapered notches therein, said tapered notches decreasing progressively in width from the open to the closed ends thereof and having a constricted portion of at least 2" in length adjacent the closed ends thereof of width to prevent entry therein of alternating current arcs of a predetermined instantaneous current magnitude, means for establishing an arc within said notches, and means of magnetic material for moving the arc into the constricted portion of said notches following decay of the instantaneous value of the arc current below said predetermined magnitude where it is cooled and extinguished, said means of magnetic material being positioned only adjacent the closed ends of said notches for progressively exerting a greater force upon the arc as it moves towards the closed ends of said notches.

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