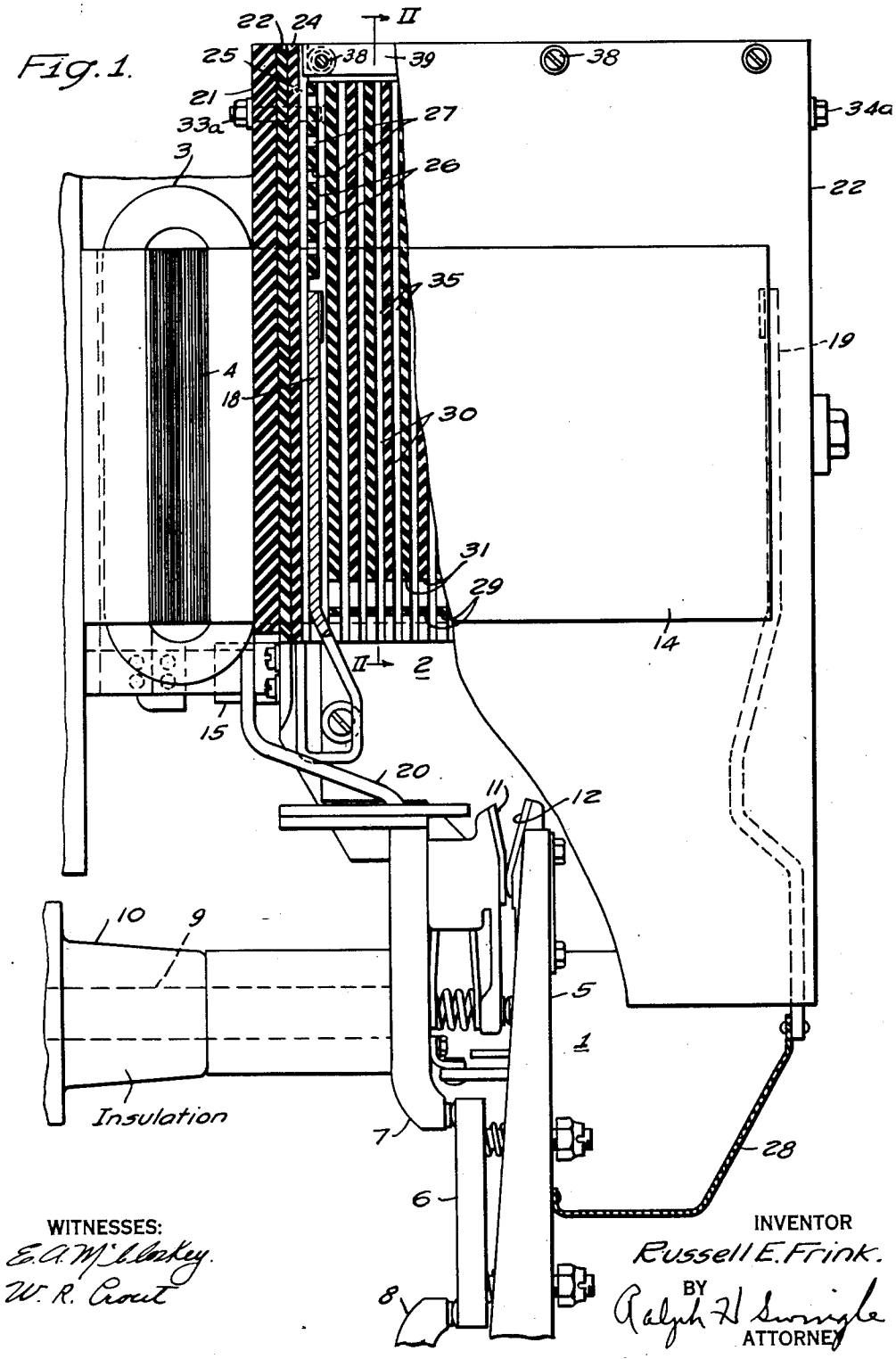
Oct. 28, 1952 R. E. FRINK 2,616,006

AIR BREAK CIRCUIT INTERRUPTER

Filed Feb. 28, 1947 3 Sheets-Sheet 1

Fig. 1.



WITNESSES:
E. A. McCloskey.
W. R. Crout

INVENTOR
Russell E. Frink.
BY
Ralph H. Swingle
ATTORNEY

Oct. 28, 1952 R. E. FRINK 2,616,006

AIR BREAK CIRCUIT INTERRUPTER

Filed Feb. 28, 1947 3 Sheets-Sheet 2

Fig. 2.

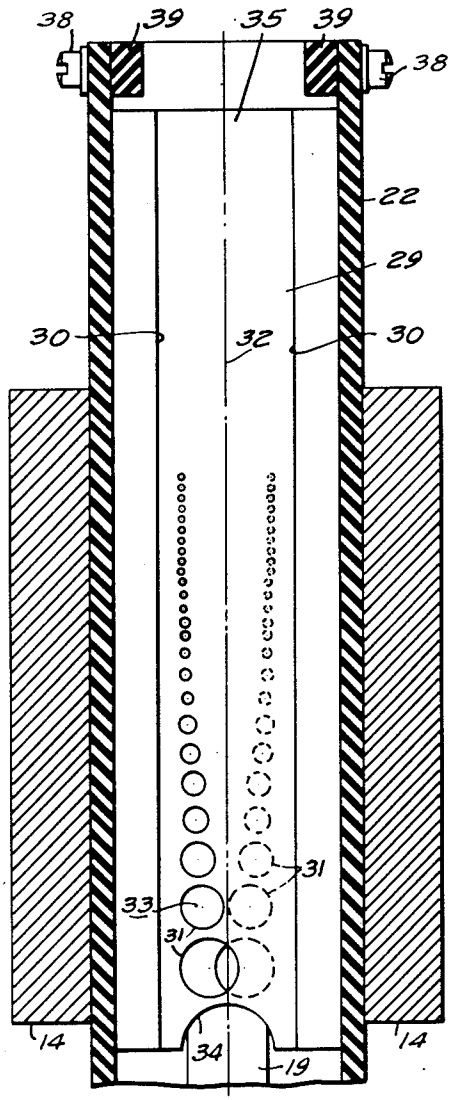
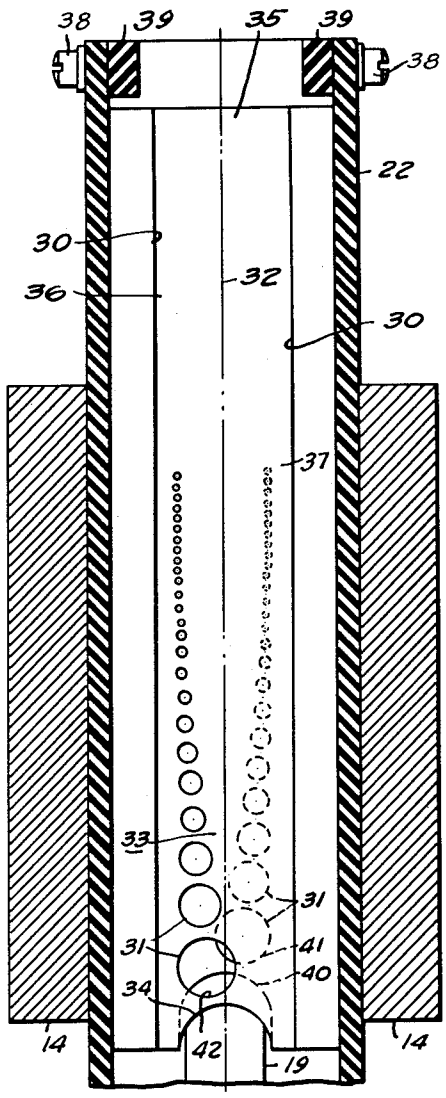


Fig. 3.



WITNESSES:

E. A. McCloskey

W. R. Crouch

INVENTOR

Russell E. Frink.

BY

Ralph H. Swingle

ATTORNEY

Oct. 28, 1952 R. E. FRINK 2,616,006

AIR BREAK CIRCUIT INTERRUPTER

Filed Feb. 28, 1947 3 Sheets-Sheet 3

Fig. 4.

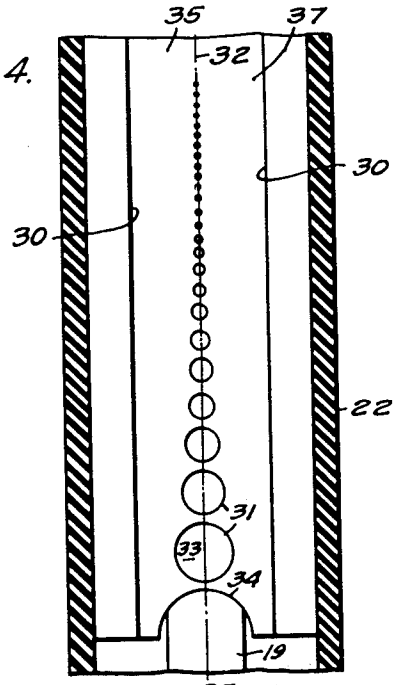


Fig. 5.

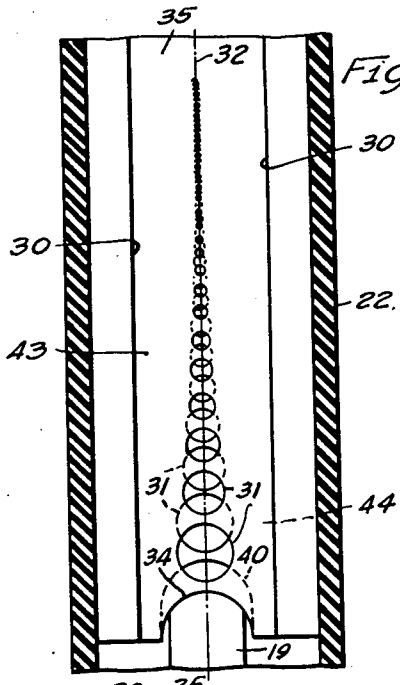


Fig. 6.

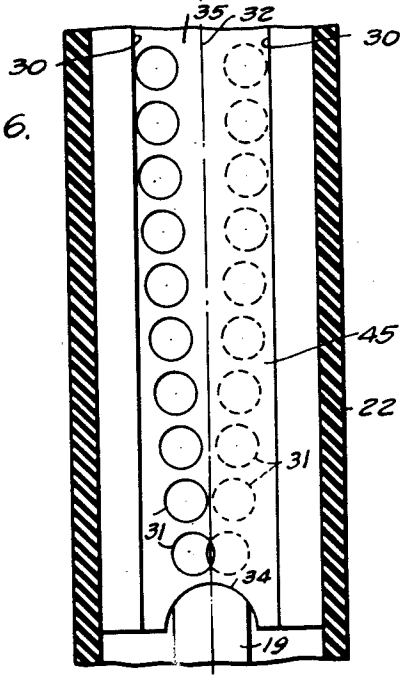
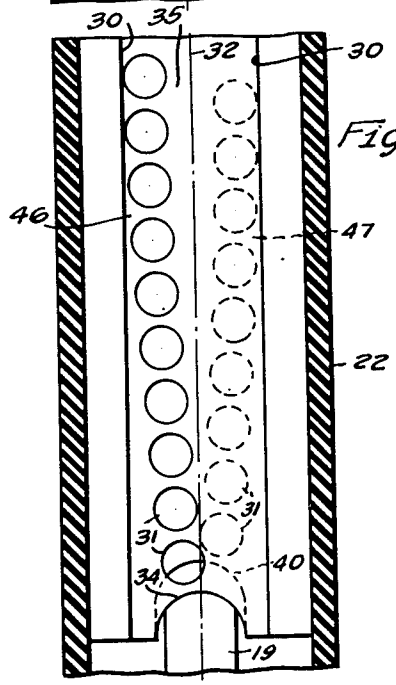


Fig. 7.



WITNESSES:
E. A. McCloskey
W. R. Crout

INVENTOR
Russell E. Frink.

BY
Ralph H. Swingle
ATTORNEY

Patented Oct. 28, 1952

2,616,006

UNITED STATES PATENT OFFICE

2,616,006

AIR BREAK CIRCUIT INTERRUPTER

Russell E. Frink, Pittsburgh, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application February 28, 1947, Serial No. 731,639

9 Claims. (Cl. 200—144)

1

This invention relates to improvements in circuit interrupters, and more particularly to arc-extinguishing structures for circuit interrupters of the air break type.

In United States patent application, Serial No. 514,362, which was filed December 15, 1943, by Robert C. Dickinson and Russell E. Frink and which issued as Patent Number 2,442,199 on May 25, 1948, and assigned to the assignee of the instant application, there is shown and described an arc-extinguishing structure for circuit interrupters of the air break type in which arc extinction is accomplished by the lateral movement of an established arc toward the closed ends of a series of tapered slots formed in spaced plates of insulating material. Lateral movement of the arc was obtained by a magnetic field produced by a magnetic blowout coil and magnetic field poles. This magnetic field was also relied upon to produce a blast of un-ionized gas through the arc while the arc is held substantially immovable against the closed ends of the slots in the plates of insulating material.

It is a general object of the present invention to improve the plate construction in an air break type of circuit interrupter of the type disclosed in the aforesaid patent application so as to make it more rugged and thereby less susceptible to breakage of the plates and also to improve the arc interrupting properties of the several plates.

Another object is to provide an improved plate construction for an air break type of circuit interrupter in which apertures or holes are provided in the plates in substantially a straight line direction away from the arc establishing means through which the arc may be permitted to play.

Still a further object of my invention is to provide an improved plate construction in which a plurality of apertures are provided in the plates and to alternately dispose the plates so as to form a staggered apertured arc passage through which the arc may be forced by the magnetic field to quickly bring about its extinction.

Still another object is to provide an improved plate construction in which the plates are provided with a plurality of apertures diverging from the center line of the plate in a direction away from the contacts and to alternately position the plates so that there is thereby provided a staggered apertured arc passage through which the arc may be forced so as to progressively lengthen the arc while at the same time forcing it to intimately engage the cool surfaces of the plates.

2

Further objects and advantages will readily become apparent upon a reading of the following specification taken in conjunction with the drawings, in which:

Figure 1 is a side elevational view, partially in vertical section, of an air break type of circuit interrupter embodying my invention and shown in the closed circuit position;

Fig. 2 is a vertical sectional view taken on the line II—II of Fig. 1;

Fig. 3 is a view similar to Fig. 2, but taken through a modified type of plate construction;

Fig. 4 is a fragmentary vertical sectional view similar to the views of Figs. 2 and 3 but showing still another modified type of plate construction;

Fig. 5 is a view similar to Fig. 4 but showing a further modified plate construction; and

Figs. 6 and 7 are views similar to those of Figs. 4 and 5 showing still additional modified types of plate construction.

Referring to the drawings, and more particularly to Fig. 1 thereof, the reference numeral 1 generall designates suitable contact structure which, when separated to the open circuit position, establishes an arc which is moved upwardly into an arc chute, generally designated by the reference numeral 2, as a result of a transverse magnetic field set up by the blowout coil 3 and associated magnet structure 4. A rotatable contact arm 5 carries a conducting bridge 6 which, in the closed circuit position, as shown in Fig. 1, interconnects stationary main contacts 7, 8.

A contact stud 9 carries the current from the stationary main contact 7, through an insulating bushing 10 to the external circuit. The contact stud for the stationary main contact 8 is not shown, but it may be identical to the contact stud 9.

Consequently, in the closed circuit position of the interrupter, as shown in Fig. 1, the electrical circuit comprises the contact stud 9, stationary main contact 7, conducting bridge 6, stationary main contact 8, to the contact stud therefor, not shown, to the external circuit.

During the opening operation of the interrupter, the contact arm 5 is rotated in a clockwise direction about a pivot point, not shown, but which is in electrical contact with the stationary main contact 8, to draw an arc between the arcing contacts 11, 12 after the separation of conducting bridge 6 from main contacts 7, 8.

When the arcing contacts 11, 12 separate, the arc formed therebetween will expand upwardly because of the loop circuit so that one terminal thereof will be transferred to the arc terminal member 13, and the other arc terminal will be

transferred to the other arc terminal member 19. When this occurs, the blowout coil 3 will be put into series circuit and the transverse magnetic field set up thereby between the field pole members 14 (Fig. 2) will move the established arc laterally upwardly along the arc terminal members 18, 19 into the arc chute 2. The electrical circuit now comprises contact stud 9, conductor 20, blowout coil 3, contact clip 15, arc terminal member 18, the arc itself, arc terminal member 19, flexible shunt 28, contact arm 5 to the other contact stud, not shown.

The arc chute 2 comprises an insulating rectangularly shaped housing member 22 positioned adjacent to an insulating plate 21, the latter serving as a base for the blowout coil 3. Within the housing 22 is placed a plate 24 composed of an insulating material. Two insulating spacer strips 25 space a plate 26, composed of an insulating material, away from the plate 24. The plate 26 may have a plurality of apertures 27 formed therein which facilitate the venting of arc gases therethrough, particularly when high currents are to be interrupted. This construction is set forth and claimed in the aforesaid patent. Two more insulating spacer strips 25 space the plate 26 from a plurality of plates 29, forming a unitary plate assembly, and which are composed preferably of a refractory insulating material such as a zircon porcelain, which does not give off gas when contacting an arc. The plates 29 have a construction more clearly shown in Fig. 2 and are separated by insulating strips 30 which provide venting passages 35 therebetween.

Above the arc terminal member 19 is a second refractory plate 26, which is spaced by spacer strips 25 from the right-hand plate 29 of the plate assembly. Two additional spacer strips 25 space the right-hand plate 26 from a refractory plate, not shown, which is in turn separated from the right-hand end of the housing 22 by a plurality of strips of fish paper. Bolts 33*a* secure the several strips 25, plate 26 and the housing 22 to the plate 21. Bolts 34*a* secure the right-hand plate 26 and its spacer strips 25 and fish paper strips to the housing 22.

The plates 29 and the spacer strips 30 are cemented together in a preliminary process to form a unitary plate assembly which may be bodily placed into the rectangular housing 22. Insulating holding strips 39 are secured by bolts 38 to the opposed inner sides of the housing 22 to prevent the unitary assembly of plates 29 from being forced upwardly out of the housing 22 by the pressure of gas formed during the interrupting operation.

Referring to Fig. 2, which more clearly shows the configuration of the insulating plates 29, it will be observed that each plate 29 has a plurality of spaced apertures 31 provided therein in substantially a straight line row of progressively smaller area in a direction away from the contacts and toward the top of the plate 29. The apertures 31 diverge away from the center line 32 of the plate 29 in a direction away from the contacts and toward the upper end of the plate 29.

The preferred construction is to alternately position the plates 29 within the chute structure 2 so as to form a horizontally staggered apertured arc passage generally designated by the reference numeral 33 in Fig. 2. A recess 34 is provided at the lower end of each plate 29.

The opening operation of the interrupter will now be explained. Upon the clockwise rotation of the contact arm 5, an arc is drawn between the arcing contacts 11, 12 which quickly transfers, because of the loop circuit, to the arc terminal members 18, 19 to thereby contact into series circuit the blowout coil 3. The magnetic field set up by the blowout coil 3 between the field pole members 14 forces the established arc upwardly along the arc terminal members 18, 19 until it comes in contact with the lower edges of the plates 29. The magnetic field gives an upward component of velocity to the electrons which bombard gas particles and impart to them an upward velocity. This magnetically produced gas blast carries ionized gas upward so that sufficient ionization exists above the arc in the spaces 35 in the vicinity of the first apertures 31 that the potential between terminals 18, 19 maintained by the arc voltage drop will cause an arc to be established through the first apertures 31. There are now two arcs in parallel, one through the space adjacent recesses 34 and one through the first apertures 31. However, the magnetically produced gas blast is carrying ions from the arc at 34 to the arc through the apertures 31 while the arc at 34 receives no such reinforcement. As this action continues the arc will transfer entirely from 34 to 31 and in the same manner to the next higher series of apertures. This action is very rapid and the arc can be carried from the space 34 to the upper apertures in a half cycle or less. It will be observed the deionizing action upon the arc in the apertures successively occupied is progressively greater due to one or both of two reasons. As the apertures become successively smaller the ion velocity must increase in order to maintain the current. This increased velocity makes the field more effective as can be seen from the formula

$$r = \frac{mv}{eB}$$

where r is the radius of the spiral described by the charged particle, m is the mass of the particle, v the velocity, e the charge and B the magnetic field strength, all expressed in appropriate units. From this formula, it is evident that, other quantities remaining the same, the upward component of velocity of the electrons will be proportional to the horizontal component of velocity and the gas blast through the more restricted arc will be more intense. Also as the apertures in adjacent plates diverge from each other, the arc is lengthened and consequently subject to more total deionization over its length. This deionizing action removes ions from the arc stream so that the arc is obliged to continually ionize fresh gas. When current zero is reached, the deionizing action continues but the ionizing action momentarily ceases and interruption is accomplished.

From the foregoing description it will be apparent that the arc, drawn between the pair of arc terminal members 18, 19, is moved magnetically against the bottom edges 34 of the plates 29, and due to the magnetic blast carrying the ionized gases upwardly between the plates 29 and to the action of the magnetic field upon the arc, the arc will transfer successively to the smaller and smaller holes or apertures 31. Each time the arc is transferred to the next higher set of holes or apertures, its core is restricted to a smaller diameter and its length is increased which places it in contact with a greater area of the comparatively cool surface of the plates 29. All of this will greatly increase the arc resistance at the time of circuit interruption, which will have several

beneficial results. Among the advantages to be gained with this type of interrupting chute structure are the following:

(1) At current zero the arc is in contact with a large area of the plate surface, so deionization is more rapid and the entire structure can have a higher rating than conventional devices.

(2) The current is gradually reduced by increasing the arc resistance so that switching surges are minimized.

(3) The power factor at the time of interruption will be high, making the circuit easier to interrupt.

(4) A structure of this kind will be more rugged than conventional chute structures composed of plates having merely V-shaped slots or composed of interleaving plates, so any tendency to shatter at high current is reduced.

It has been demonstrated that in this type of interruption, the rate of dielectric recovery after current zero is greatest at the edges of the plates. From this it can readily be seen that dielectric recovery at current zero will be more rapid when the arc stream passes through an aperture and is completely surrounded by edges than when it passes through a slot in a plate or between interleaving fins or plates.

I have tested a structure of the foregoing type and have found that such an arc interrupting arrangement in which the arc successively restrikes in a series of holes or apertures in insulating plates placed perpendicularly to the arc gives very good results.

Several plans of drilling the plates 29 were used with the rate of decrease in the diameter of the holes and rate of divergence of the holes from the center line 32 varied. For example, in the modified plate construction shown in Fig. 3, the apertures 31 in the alternately disposed plates 37 were raised with respect to the apertures or holes 31 in the other plates 36. Thus, the two types of plates employed 37, 36 not only have the apertures 31 diverging away from the center line 32 and of increasingly smaller diameter in a direction toward the top of the plates and away from the contacts, but in addition, the apertures or holes in the plates 37 are raised with respect to the apertures 31 in the plates 36. More specifically the centers of the apertures 31 in the plates 37 are substantially half way inbetween the centers of the apertures 31 in the plates 36.

It will be noted that the recess 34 provided in each plate 36 is below the recess 40 provided in each plate 37. Thus, the distance between the edge of the recess 40 and the edge 41 of the first aperture 31 in a plate 37 is about the same as the distance between the edge of the recess 34 and the edge 42 of the first aperture 31 in the plate 36.

Thus, the arc in the plate structure of Fig. 3 wil be drawn within an arc passage 33 which is not only staggered horizontally and becomes progressively smaller toward the upper end of the plates 37, 36 but is formed of apertures 31 which are staggered in a vertical direction as well.

Fig. 4 shows a modified type of plate construction utilizing a plurality of spaced plates 37, each of which has the recess 34 provided at its lower end. Also each plate 37 has a plurality of progressively decreasing holes or apertures 31 positioned along the center line 32 of the plate 37 in a direction away from the contacts. The several plates 37 are all of the same kind and there is no staggering either vertically or horizontally. Thus, there is provided an arc passage 33 of progressively smaller cross-sectional area toward the upper end of the plates 37 and away from the contacts.

Fig. 5 shows a plate chute construction in which the apertures 31 are not staggered horizontally but they are staggered vertically. Thus, the chute consists of two types of plates designated by the reference numerals 43, 44, which are alternately disposed. The plates 43 have progressively decreasing apertures 31 toward the top of the plate 43, all along the center line 32 of the plate 43. The alternately positioned plates 44 have their apertures or holes 31 of such position that the centers thereof are substantially half way inbetween the centers of the holes or apertures 31 of the plates 43. Also each plate 44 has a greater upwardly extending recess 40 so that the spacing between the recess 40 and the lower edge of the first aperture 31 in the plate 44 is substantially the same as the distance between the apertures 34 and the lower edge of the first aperture 31 of the plates 43.

Fig. 6 shows a modified plate construction involving plates of only a single type but alternately disposed. Each plate 45 has a plurality of holes or apertures 31 of substantially the same cross-sectional area. The holes or apertures 31 diverge upwardly away from the center line 32 of the plate 45. Thus, the arc passage is formed of plates which are staggered horizontally but not vertically.

Fig. 7 illustrates a chute construction involving plates of two different types with both horizontal and vertical staggering. The first type of plate 46 has the holes or apertures 31 all of substantially the same size and diverging in an upward direction away from the center line 32 of the plate 46. Each of the alternately disposed plates 47 has a plurality of holes or apertures 31 which have substantially the same cross-sectional area. The holes 31 in the plates 47 diverge away from the center line 32 of the plate 47. There is thus provided horizontal staggering. Also the apertures 31 of the plates 47 have their centers substantially half way inbetween the centers of the apertures 31 of the plates 46 so as to have a vertically staggered structure. The recess 40 in the plates 47 is cut deeper than the recess 34 in the plates 46 so that the space between the upper edge of the recess and the first apertures 31 may be substantially the same in both plates 46, 47.

By way of example only, and not by way of limitation, in a series of tests made on the arc chute set forth in Figs. 1 and 2, I used from 58 to 62 plates 29 having a size of 2¾" by 17¼". The plates 29 were ⅛" thick and were spaced ⅛" apart. It was found that without use of an auxiliary air device the structure could interrupt any current from 40 amperes up to the interrupting limit, and it is thought that an auxiliary air cylinder, such for example as that set forth in my copending application, Serial No. 692,331, filed August 22, 1946, now U. S. Patent No. 2,491,964, issued December 20, 1949, and assigned to the assignee of the instant application, would extend the range down to zero. Many power interruptions were made and the maximum value of successful interruptions obtained was 5,960 amperes at 13,200 volts and 19,650 amperes at 9,000 volts, the tests being single phase and at practically zero power factor.

It is apparent that among the advantages of this plate structure compared with the slotted plate type of interrupter are that the plate structure is stronger and consequently the tendency

for breakage is less, and in addition there is less tendency for the arc to restrike in the lower parts of the arc chute 2 because of the enhanced deionization between the holes or apertures.

Although I have shown and described specific structures, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. In a circuit interrupter of the air break type, means for establishing an arc, a plurality of thin closely spaced parallel plates of insulating material disposed substantially transversely of the established arc, the spacing between the parallel disposed plates being substantially equal to the thickness of the plates, at least some of the spaced plates having a plurality of spaced closed apertures formed therein and free venting spaces therebetween to vent the arc gases freely, the spaced closed apertures extending in substantially a straight line away from the arc establishing means, means for moving the established arc substantially transversely against the plates and through the spaced closed apertures to effect the extinction thereof, and a body of air around and between the spaced plates to permit free movement of the established arc.

2. In a circuit interrupter, means for establishing an arc, an arc chute including a plurality of thin closely spaced parallel plates of insulating material disposed substantially transversely of the established arc and having free venting spaces therebetween for freely venting the arc gases, the spacing between the parallel disposed plates being substantially equal to the thickness of the plates, at least some of the spaced plates having a plurality of holes formed therein spaced at different distances away from the means and extending in substantially a straight line therefrom, mean for moving the arc substantially transversely of the spaced plates and successively through the holes in the plates to effect the extinction thereof, and said arc chute having therein an ambient of gas.

3. In a circuit interrupter, means for establishing an arc, arc extinguishing means including a plurality of thin closely spaced parallel plates of insulating material disposed substantially transversely of the established arc and having free venting spaces therebetween for freely venting the arc gases, the spacing between the parallel disposed plates being substantially equal to the thickness of the plates, each plate having formed therein a plurality of spaced progressively diminishing size holes in a substantially straight line direction away from the arc establishing means, means for moving the arc in said direction substantially transversely of the spaced plates and successively through the holes to effect the extinction thereof, and a body of air around and between the spaced plates to permit free movement of the established arc.

4. In a circuit interrupter of the air break type, means for establishing arcing, an arc chute including a plurality of thin closely spaced parallel plates of insulating material disposed substantially transversely of the arcing and having free venting passages therebetween, the spacing between the parallel disposed plates being substantially equal to the thickness of the plates, each plate having a plurality of spaced holes of gradually diminishing size in a substantially straight line direction away from the arc establishing means and diverging away from the center line of the plate in said direction, the plates being alternately positioned so as to form an upwardly decreasing size horizontally staggered apertured arc passage, means for moving the arcing in said direction within the apertured arc passage, and said arc chute having therein an ambient of gas.

5. In a circuit interrupter, means for establishing arcing, a plurality of thin closely spaced parallel plates formed of insulating material disposed substantially transversely of the arcing and having free venting passages therebetween, the spacing between the parallel disposed plates being substantially equal to the thickness of the plates, the plates being of two types and alternately positioned, one type having a plurality of spaced holes extending in a row of progressively decreasing size in a substantially straight line direction away from the arcing establishing means and divergingly away from the center line of the plate in said direction, the other type being of similar configuration but the centers of the spaced holes being staggered with respect to the first-mentioned type in said direction, the result of the assembly being a decreasing size apertured arc passage in said direction staggered vertically as well as horizontally, means for moving the arcing within the arc passage substantially transversely of the plates in said direction to effect the extinction thereof, and a body of air around and between the spaced plates to permit free movement of the established arc.

6. In a circuit interrupter, means for establishing arcing, a plurality of thin closely spaced parallel insulating plates disposed substantially transversely of the arcing and having free venting passages therebetween, the spacing between the parallel disposed plates being substantially equal to the thickness of the plates, each plate having a plurality of spaced closed apertures formed therein positioned in a row along substantially the center line of the plate and of progressively decreasing size in a direction away from the arcing establishing means, the alignment of the several plates creating an apertured arc passage which is more and more constricted in said direction but is neither staggered horizontally nor vertically, means for moving the arcing substantially transversely of the plates in said direction within the arc passage, and a body of air around and between the spaced plates to permit free movement of the established arc.

7. In a circuit interrupter, means for establishing arcing, a plurality of thin closely spaced parallel plates formed of insulating material disposed substantially transversely of the arcing and having free venting passages therebetween, the spacing between the parallel disposed plates being substantially equal to the thickness of the plates, the plates being of two types and alternately positioned, one type having a plurality of spaced holes extending in a row of progressively decreasing size substantially along the center line of the plate in a direction away from the arcing establishing means, the other type being of similar configuration but the centers of the spaced holes being staggered with respect to the first-mentioned type in said direction, the result of the assembly being a decreasing size apertured arc passage staggered in said direction, means for moving the arcing substantially transversely of the plates in said direction within the arc passage to effect the extinction thereof, and a

body of air around and between the spaced plates to permit free movement of the established arc.

8. In a circuit interrupter, means for establishing arcing, a plurality of thin alternately disposed insulating closely spaced parallel plates positioned substantially transversely of the arcing and having free venting passages therebetween, the spacing between the parallel disposed plates being substantially equal to the thickness of the plates, each plate having a plurality of spaced closed apertures in a row of substantially the same size and diverging away from the center line of the plate in a substantially straight line direction away from the arcing establishing means, means for moving the arcing substantially transversely of the plates and successively through the apertures in said direction, and a body of air around and between the spaced plates to permit free movement of the established arc.

9. In a circuit interrupter of the air break type, means for establishing arcing, an arc chute having an apertured arc passage formed therein staggered vertically as well as horizontally and including a plurality of thin alternately disposed closely spaced parallel insulating plates positioned substantially transversely of the arcing and having free venting passages therebetween, the spacing between the parallel disposed plates being substantially equal to the thickness of the plates, the plates being of two types, one type having a plurality of spaced closed apertures of substantially the same size diverging away from the center line of the plate in a direction away from the arcing establishing means, the spaced closed apertures extending in substantially a straight line row away from the arc establishing means, the other type being similar but having the centers of the spaced closed apertures staggered in said direction with respect to the first type of plate, means for moving the arcing substantially transversely of the plates and successively through the closed apertures, and said arc chute having therein an ambient of gas.

RUSSELL E. FRINK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,497,424	Aalborg	June 10, 1924
2,051,196	Barfoed	Aug. 18, 1936
2,138,391	Van Sickle	Nov. 29, 1938
2,243,039	Ludwig et al.	May 20, 1941
2,244,061	Graves	June 3, 1941
2,311,690	Pokorny	Feb. 23, 1943
2,372,045	Armstrong	Mar. 20, 1945
2,408,352	Titus	Sept. 24, 1946
2,443,650	Berkey	June 22, 1948

FOREIGN PATENTS

Number	Country	Date
797,227	France	Feb. 8, 1936