July 27, 1937. J. SLEPIAN 2,088,489

CIRCUIT INTERRUPTER

Filed March 16, 1934 2 Sheets-Sheet 1

Fig. 1.

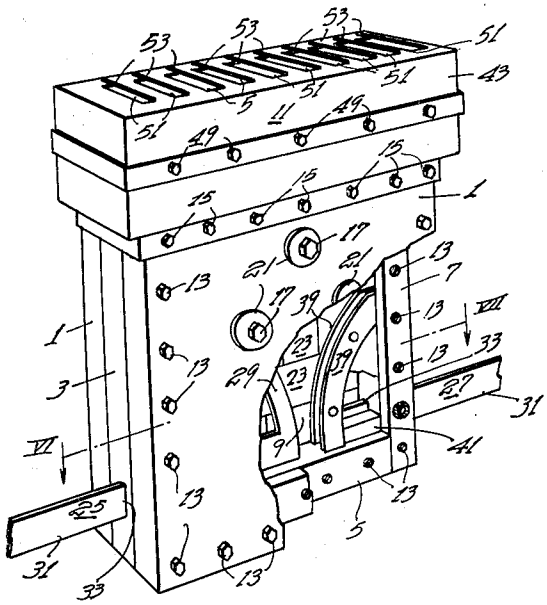


Fig. 2.

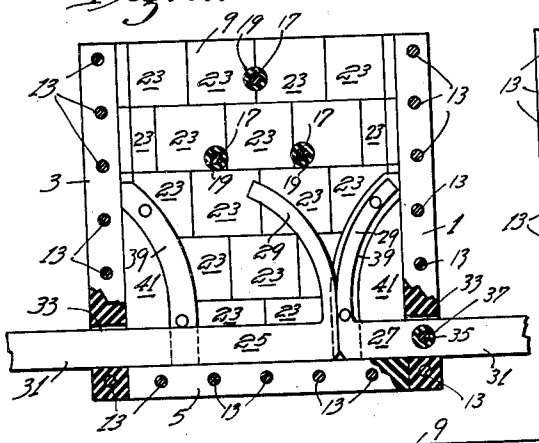


Fig. 3.

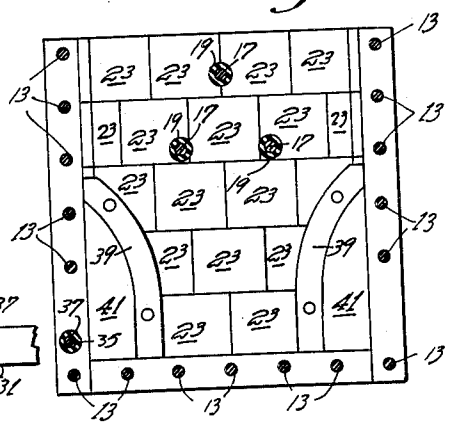
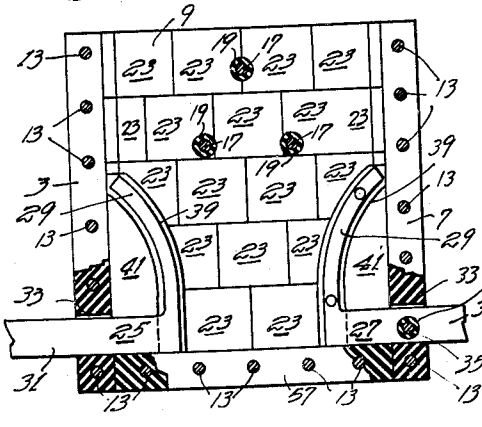


Fig. 4.



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CIRCUIT INTERRUPTER

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Fig. 5.

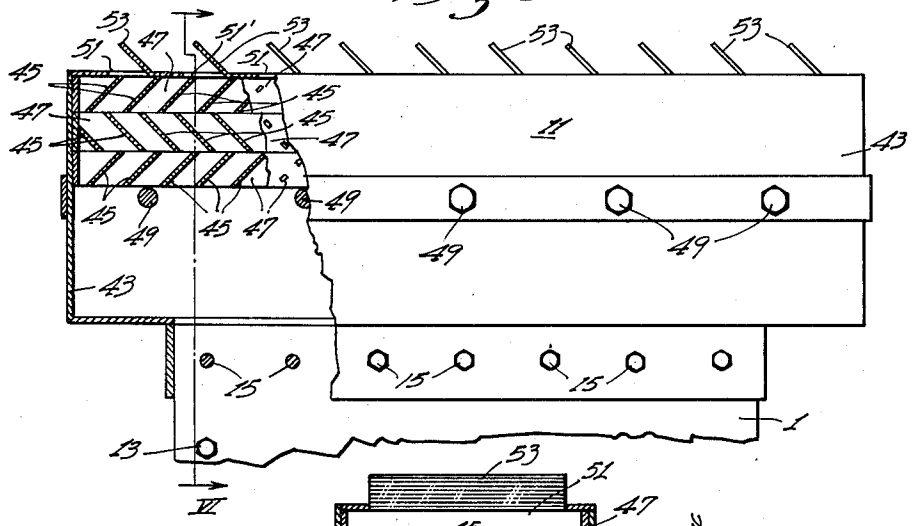



Fig. 6.

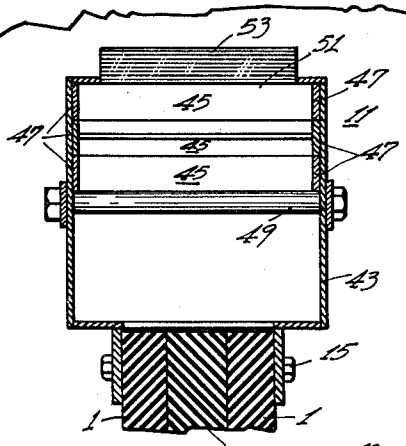



Fig. 8.

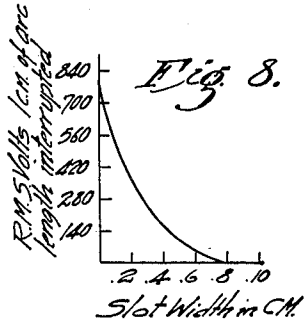



Fig 7.

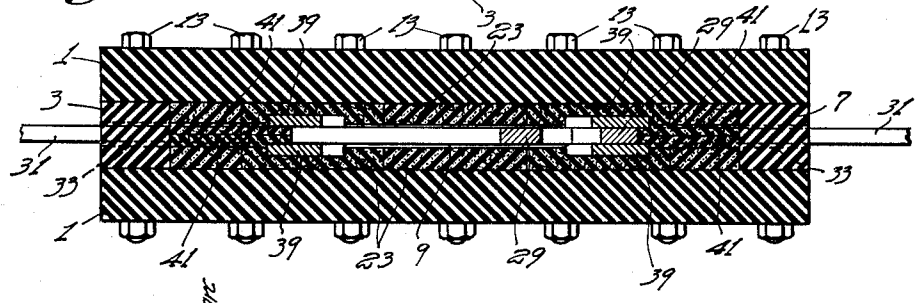
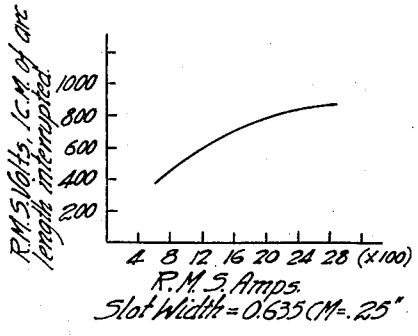



Fig 9.

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Patented July 27, 1937 2,088,489

# UNITED STATES PATENT OFFICE

2,088,489

## CIRCUIT INTERRUPTER

Joseph Slepian, Pittsburgh, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application March 16, 1934, Serial No. 715,817

12 Claims. (Cl. 200—144)

My invention relates generally to circuit interrupters and particularly to circuit breakers wherein the arc which is established incident to the opening of the controlled circuit is extinguished within a slot-type arc extinguisher under the influence of a blast of arc extinguishing gas.

It has been known in the past that a very considerable increase in the voltage per centimeter of arc length that can be successfully interrupted by a particular circuit breaker might be effected through the provision of a slot-type arc chute, having insulating walls of a refractory material. The development of such devices for use with high voltage and high current circuits has been attended with such difficulties, however, that successful interrupters for use with circuits of more than a few hundred or a thousand volts have been commercially impracticable. These difficulties are pointed out in detail below and the obviation of them is the principal object of my invention.

An investigation of the properties and characteristics of this type of arc extinguishing device shows that in a slot chamber having walls of a refractory insulating material, the voltage per centimeter of arc length which can be successfully interrupted varies inversely with the thickness of the slot (about as shown in the curve of Fig. 8). Obviously, if the voltage per centimeter of arc length which can be interrupted by the device is to be increased, so that a high voltage circuit can be opened without excessive periods of arcing, very narrow slot widths must be used. For example, to obtain an interrupting capacity of 500 volts per centimeter length of arc, a slot width of 1 millimeter must be used. If such a slot width is used, however, it becomes a very difficult matter to force the arc into the slot. The separating contacts, of course, cannot be disposed within such a narrow slot, and the arc must be established externally of the narrow passageway, usually below that passageway. Then a means, such as a suitably disposed magnetic field, must be used to drive the arc upwardly into the narrow slot passage. The strength of a magnetic field capable of accomplishing this movement has been found to be excessively large, the strength in gausses being several times the magnitude of the arc current in amperes, which is to say that a coil of many turns embracing the whole slot structure is necessary. For large currents, therefore, this coil would necessarily be made of massive conductors. It would be heavy and expensive, and would be difficult to brace so as to withstand the large mechanical forces arising from the magnetic effects of the large currents flowing therethrough.

I have found, however, that if the walls of the slot passage are made of non-refractory insulating material of a kind which evolves a considerable quantity of an arc extinguishing gas when placed in proximity to an electric arc a great increase in the voltage per centimeter of arc length which can be interrupted in a slot of given width is effected, particularly at high currents. These experimental results show that for an arc current of 2000 amperes more than 800 volts per centimeter of arc length can be interrupted as compared with only 60 volts per centimeter of arc length obtained with a slot of like width between refractory walls.

The reason for this superior performance of the device utilizing gas evolving walls lies, I believe, in the effect of the gas given off by the walls of the slot passage upon the state of the arc. This gas mixes turbulently with the arc during the period of arc extinction, and so alters its character that the arc is extinguished at a current zero, even in the circuit of high voltage.

I have also found that the nature of the gas given off by the lining of the slot passage has a considerable influence on the voltage per centimeter of arc length which can be interrupted. Hydrogen and water vapor, for example, are particularly effective in producing an increase in this voltage. Hydrogen is given off in considerable quantities from a lining composed of an organic material such as fiber, and water vapor is given off by my preferred material, boric acid. In practicing my invention, therefore, I provide a circuit interrupter having a slot passage or chamber of narrow width and means for establishing an arc within that chamber. However, in contrast to the previously used forms of narrow slot arc extinguishers wherein the passageway is lined with a refractory material, I provide a device wherein a substantial portion of at least one of the opposed inner surfaces of the passageway is lined with a solid material which is capable of evolving an arc extinguishing gas when placed in proximity to an electric arc.

The provision of this gas evolving lining greatly increases the voltage which can be interrupted by a given length of arc. Moreover, the effective range of current values which may be successfully interrupted is greatly increased, due to the fact that the amount of arc extinguishing gas produced is a function of the arc current itself. Thus, when the current magnitude of the arc to

be extinguished increases the device automatically provides more gas for extinguishing the arc.

The previously mentioned experimental results further show that the gain which is attained in the voltage interrupting capacity of the device through the use of a gas evolving lining for the arc passage is very large for the larger magnitude currents, but becomes less for the currents of smaller magnitude (substantially according to the curve of Fig. 9). Because of this characteristic, it is necessary to cause a very considerable lengthening of the arc when interrupting low magnitude currents at high voltages. Generally, it is impractical to draw such long arcs directly, and it is, therefore, desirable to provide a pair of arcing horns along which the arc terminals may move to effect a longitudinal increase in the dimensions of the arc.

It is possible to cause the arc to move along these horns by a suitable magnetic field, which augments the magnetic effect inherent in all curved arc horns. However, as I have stated above, the coils for such a magnetic field are extremely large, very heavy, and very expensive if they are to carry large currents. Therefore, in the preferred form of my invention, I provide means for dispensing with an external magnetic field and effect the movement of the arc along the horns through the proper directing of the blast of arc extinguishing gas which is evolved from the lining of the arc passage.

Accordingly, a further object of my invention is to provide an improved slot-type arc extinguishing device, the inner surfaces of which are lined with a gas evolving material with means for so directing the flow of arc extinguishing gas through the arc passage that the arc is moved along the horns and lengthened to a degree sufficient to interrupt the circuit. This object is accomplished in the preferred form of my invention by the complete enclosing of the arc extinguisher, except on the side toward which the arc is to be moved along the arc horns.

During the use of circuit interrupters wherein the extinction of the arc is effected by the flow of a blast of arc extinguishing gas through the arc, a considerable volume of flame is formed if such gas is vented immediately after leaving the arc passage. This flame is, of course, dangerous if it is liberated in proximity to any electrical apparatus, because it has low dielectric strength and will short circuit voltage-bearing parts. It is very important, therefore, that means be provided for preventing injury to adjoining equipment by this heated gas, and another object of my invention is to provide means for preventing an unreasonable amount of flame from being emitted from the arc passage of a narrow-slot type circuit interrupter during the operation of the device.

This object of my invention is accomplished through the provision of a flame suppressor wherein the out-flowing gas is caused to vent through circuitous passages formed within suitable metallic baffle members. These members abstract heat from the arc and prevent the temperature of the venting gas from reaching a dangerously high value.

By using boric acid as the gas evolving material, another important advantage is obtained with relation to the flame suppressor. The gas evolved by the heated boric acid lining is substantially entirely water vapor, and when this gas reaches the cold surfaces of the flame suppressor, the gas is condensed to water and the volume of the vented gas is reduced to a minimum. In fact, if sufficient cooling surface is provided within the flame suppressor, the entire circuit interrupter may be entirely enclosed and no gas will leave the device whatsoever during the circuit interrupting operation. Undue pressures will not be developed within the arc passage because the gas will be condensed to liquid water in the flame suppressor, which might then be more properly termed a condenser.

A still further object of my invention is to provide an improved contact and arc horn structure that is particularly suitable for use with slot-type arc extinguishing devices generally.

An ancillary object of my invention is to provide an improved lining for the inner surfaces of the arc passage of a narrow-slot arc extinguishing device, my improved lining to increase the arc extinguishing efficiency of the device and to minimize the danger from fire or the like.

These and other objects of my invention will be made more apparent by reference to the accompanying drawings, wherein:

Figure 1 is a perspective view, with portions broken away, of a narrow slot circuit interrupter embodying the principal features of my invention. The circuit interrupter is provided with a flame suppressing device.

Fig. 2 is an elevational view of one of the two wall members which, together, make up the narrow-slot arc extinguisher of the circuit breaker shown in Fig. 1. The contacts of the breaker are also illustrated in this view and are shown in the fully closed position;

Fig. 3 is an elevational view of the other wall defining member, which, in conjunction with the member shown in Fig. 2, makes up the arc extinguisher of the circuit interrupter shown in Fig. 1;

Fig. 4 is a view similar to Fig. 2, except that the contacts are in the fully open position;

Fig. 5 is a fragmentary elevational view, partially in section, of the flame suppressing device and the circuit interrupter illustrated in Fig. 1;

Fig. 6 is a sectional view taken on the line VI—VI of Fig. 5;

Fig. 7 is a sectional view taken on the line VII—VII of Fig. 1;

Fig. 8 is a curve which shows the relationship between the slot width and the voltage per centimeter of arc length which can be successfully interrupted within narrow slot circuit interrupters utilizing refractory walls; and

Fig. 9 shows the relationship between the arc current in amperes and the arc voltage per centimeter of arc length for a narrow slot circuit interrupter utilizing a gas evolving lining for the arc passage. The curve illustrates data obtained from a device utilizing a slot passage formed by a pair of fiber walls ¼'' apart.

The preferred embodiment of my invention illustrated in the drawings comprises generally a pair of wall defining members 1 of insulating material which are adapted to be spaced apart by three rectangular members 3, 5 and 7, likewise of insulating material, to form a narrow passageway 9. This passageway 9 is open at the top, which is the direction toward which the arc is moved during the normal operation of the device, and is substantially closed on the other three sides by the spacing members 3, 5 and 7. A flame suppressor 11, which is shown partly in Figs. 5 and 6, is supported upon the upper portion of the device so as to form a continuation of the arc passage 9 and serves to prevent an

undue discharge of highly heated gas during the operation of the interrupter.

A plurality of bolts 13, which extend through suitable openings in the wall defining members and the spacing members, are provided for holding those members in position. A similar set of bolts 15 is provided for bolting the flame suppressor onto the top portion of the arc extinguishing device so as to form a substantially gas-tight seal.

During the operation of slot circuit interrupters which use a gas evolving lining for the arc passage, especially when those devices are used in conjunction with a flame suppressor, rather considerable pressures may be developed within the arc passage, due to the liberation of large amounts of gas from the lining, and in order to prevent bulging of the walls of the device it may be necessary or desirable to provide means, such as the three bolts 17, which extend through insulating sleeves 19 positioned in the wall members 1, for minimizing this bulging. The metallic washers 21 serve to increase the effective contact area of the bolts.

The inner surface of each of the two wall members 1 is lined with a plurality of tile-like members 23 of compressed boric acid which are cemented or otherwise securely affixed to the opposed inner surfaces of those members. By dividing the lining up into a plurality of separate members, the servicing of the device is considerably simplified, since excessive erosion of the lining, which may take place during the interruption of abnormally large currents, will undoubtedly be confined to a rather limited area, and it will be necessary to replace only a few of the individual tile-like members in order to restore the device to its previous condition.

The contact structure is comparatively simple and comprises a pair of separable contacts 25 and 27, one of which (27) is normally stationary, and the other of which (25) is adapted to move to open and to close the electrical circuit through the interrupter. Each of the contacts is provided with an arcing horn 29 and a body portion 31 adapted to extend through a suitable opening 33 within the adjacent spacing members. The right-hand contact 27 is rigidly affixed to the spacing and wall members by means of a suitable bolt 35 and insulating tube 37. The other contact 25 is moved by a suitable actuating mechanism, not shown, from one position to the other, and the opening 33 within the spacing member aids in guiding this movement.

A pair of flat iron members 39 of somewhat larger surface area than the arcing horns 29 are embedded in the lining of the arc passage adjacent the position occupied by each of the arc horns 29 when the circuit interrupter is in the normal open circuit position. These iron members 39 serve to augment the magnetic effect of the curved arcing horns 29 so as to facilitate the movement of the arc in the direction of the upper end of the narrow passageway 9 during the arc extinction operation. In order to prevent any appreciable amount of gas being trapped in the lower portion of the passageway 9, the space between the arc horns 29 and the spacing members 3 and 7 is normally occupied by a pair of members 41 of fibre or other insulating material, which are shown particularly in Fig. 7.

Both of the contacts are formed from sheet conducting material preferably copper, having a width only slightly less than the width of the narrow passageway 9, wherein one of them moves. Despite this narrowness of the contacts, they have a considerable cross-sectional area and are capable of handling rather large magnitude currents over a considerable period of time without undue heating. Also, the arrangement is one which imparts considerable rigidity to those members.

The flame suppressor 11 consists essentially of a closed metallic box structure 43, which is adapted to form a continuation of the arc passageway 9, and wherein are contained a plurality of metallic baffle members 45 which abstract heat from the outflowing gases during the arc extinguishing operation and cause them to condense to liquid if they are condensable. The lower portion of the main closure 43 for the flame suppressor is of substantially the same dimensions as the upper portion of the narrow-slot arc extinguisher and is adapted to be supported thereon by the bolts 15 as mentioned above. The baffle members 45 are arranged between suitable side members 47 in a unit construction which is somewhat ladder-like in form. In the embodiment illustrated in the drawings, there are three of these units illustrated.

Each of the baffle members 45 is riveted or otherwise securely affixed to the side members 47, and the three complete assemblages are disposed in the upper portion of the closure 43 for the flame suppressor, five through bolts 49 being provided for holding the baffle units in place. The upper portion of the closure 43 is provided with a plurality of vent openings 51, formed by punching out sections 53 of the closure itself, in order to prevent the building up of too high pressures within the arc passage 9. The individual baffle plates 45 may be formed of copper, that metal having a high thermal capacity and excellent heat conductivity, and they are preferably arranged so that the outflowing gas follows a circuitous passage in venting through the vent openings 51.

The circuit breaker contacts are shown in the closed-circuit position in Fig. 2. During the circuit-opening operation, the moving contact 25 is moved by the operating mechanism from the position shown in Fig. 2 toward the position shown in Fig. 4. The initial portion of this movement causes the current-carrying contact surfaces to be separated whereupon an arc is established therebetween. The magnetic effect of the arcing horns 29, augmented by strips of iron 39 disposed on either side of the stationary arcing horn, immediately moves the arc in the direction of the upper portion of the narrow slot 9. Simultaneously, the heat of the arc decomposes the adjacent surfaces of the tile-like members 23 which make up the boric acid lining of the arc passageway and effects the liberation of a considerable quantity of steam, which, in venting, flows outwardly substantially transversely of the arc and carries the arc upwardly along the horns.

The lining of the passageway 9 is preferably of boric acid, as stated above, because that material when placed in proximity to an electric arc evolves a large quantity of water vapor, an arc extinguishing gas which is substantially inorganic in composition. This reduces the fire hazard and adds much to reliability of the device. Another desirable characteristic of boric acid arises from the fact that boric acid does not lose its normal high insulating properties when heated to its melting point. This prevents flashover across the lining of the arc passage even though the boric acid surface is heated to a very high

temperature. It is, of course, within the province of my invention that other solid materials for securing this gas blast may be used.

A formal discussion of the curves of Figs. 8 and 9 has been omitted from the foregoing description of the figures of the drawings, chiefly because the experimental results shown in those figures are discussed in the introductory portion of the specification. Both figures are believed to be self explanatory.

From the foregoing, it will be seen that I have disclosed a new and improved circuit interrupter which utilizes a slot arc extinction chamber much more effectively than the devices previously known to the art. By virtue of the gas producing lining which I have provided, my improved circuit interrupter is capable of efficient operation of a very much wider range of arc current values and in circuits of much higher voltage than the previously known devices, and at the same time, it is relatively simple in design and inexpensive to manufacture. Moreover, I have disclosed an improved contact structure which is particularly suitable for use with all types of slot circuit interrupters wherein relatively heavy currents have to be carried during the normal operation of the device.

In addition to the improved form of slot arc extinguishing device which I have disclosed in the foregoing description of a preferred embodiment of my invention, I have shown how a flame suppressing device may be added to a slot arc extinguisher for the purpose of preventing flashover between adjacent units and for preventing undesirable quantities of highly ionized and heated gas from being liberated during the operation of the circuit interrupter. This new combination of a slot-type circuit interrupter and flame suppressor is one which is of great value in increasing the safety and reliability of the devices, and will unquestionably prove a major factor in promoting the commercial use of these structures.

While in accordance with the patent statutes I have disclosed the foregoing details of the preferred embodiment of my invention, it is to be understood that many of these details are merely illustrative and that variations in their precise form will be necessary and desirable to certain applications. It is my desire, therefore, that the language of the accompanying claims shall be accorded the broadest reasonable construction that my invention shall be limited only by what is expressly stated therein and by the prior art.

I claim as my invention:

1. In a circuit interrupter, means defining a pair of wall members, means for supporting said wall members in proximity to each other so as to define a narrow passageway open at one end and closed at the other, a substantial portion of the inner surface of at least one of said wall defining members being lined with a material capable of evolving an arc extinguishing gas when placed in proximity to an electric arc, and separable contact members of substantially rectangular cross-section adjacent the closed end of said passageway for establishing an arc therein, the smaller dimension of said contact members being substantially equal to the width of said passageway, the gas evolved by the action of said arc upon said lining material moving said arc laterally toward the open end of said passageway.

2. In a circuit interrupter, means including a pair of oppositely disposed wall members for defining a narrow slot-like passage, a substantial portion of the inner surface of at least one of said wall members being lined with a material which gives off a gas when acted upon by an arc to aid in extinguishing the arc, separable contact members disposed between said wall members for drawing an arc within said narrow passage, said contact members being substantially of the same width as said passage, said passage having a width such that arcs of low as well as of high current magnitude are compelled to contact the walls defining the passage, a pair of opposing arc terminal members disposed between said wall members of substantially the same width as said passage and providing arc paths over which the respective ends of the arc are adapted to be moved, and means for venting said passage in such manner that the gas evolving from said lining moves the arc laterally with the ends thereof over the paths provided by said arc terminal members.

3. In a circuit interrupter, means including a pair of oppositely disposed plate members for defining a narrow passageway, said passageway being substantially completely enclosed except for venting means located adjacent one end thereof, a substantial portion of the inner surface of at least one of said plate members being lined with a material which is capable of evolving an arc extinguishing gas when placed in proximity to an electric arc, and separable contact members for establishing an arc within said passageway, said contact members having a thickness substantially equal to the width of said passageway, said venting means being disposed to cause the gas evolved by the action of the arc upon said lining to flow through the arc and move it laterally within the passageway toward said venting means.

4. In a circuit interrupter, means including a pair of oppositely disposed plate members for defining a narrow passageway, said passageway being substantially completely enclosed except for venting means located adjacent one end thereof, a substantial portion of the inner surface of at least one of said plate members being lined with a material which is capable of evolving an arc extinguishing gas when placed in proximity to an electric arc, and means including a pair of separable contacts for establishing an arc within said passageway, each of said separable contacts including an arc horn normally disposed within said passageway, and means of magnetic material partially surrounding said arc horns for aiding the gas formed by the action of the arc upon said lining to move said arc laterally on said arc horns.

5. In a circuit interrupter, means including a pair of wall members spaced apart a distance not substantially greater than one-fourth of an inch defining an arc chute, at least a substantial portion of said wall defining means being lined with a solid material that is capable of evolving an arc extinguishing gas when exposed to an electric arc, contact means movable within said chute for drawing an arc therein, and means of magnetic material for lining other portions of said wall members for causing said arc to be moved laterally within said chute to effect its extinguishment.

6. In a circuit interrupter, means including a pair of oppositely disposed wall members for defining an arc chute, at least a substantial portion of the inner surface of said wall defining means being lined with a solid material that

is capable of evolving an arc extinguishing gas when placed in proximity to an electric arc, means for establishing an arc within said chute, diverging arc horns disposed within said chute for providing terminals for the ends of said arc, and magnetic means partially surrounding said arc horns for causing said arc to be moved laterally on said arc horns to effect its extinguishment.

7. In a circuit interrupter, means including a pair of oppositely disposed wall members for defining an arc chute having the substantial form of a narrow rectangular parallelopiped, at least a substantial portion of the inner surface of said wall defining means being lined with a solid material which is capable of evolving an arc extinguishing gas when placed in proximity to an electric arc, means for establishing an arc within said chute, diverging arc horns disposed within said chute for providing terminals for the ends of said arc, and means of magnetic material partially surrounding said arc horns for causing said arc to be moved laterally on said arc horns thereby lengthening it to effect its extinguishment during each operation of said interrupter.

8. In a circuit interrupter, means including a pair of oppositely disposed wall members for defining an arc chute, at least a portion of the inner surface of said wall defining means being lined with a material which is capable of evolving an arc extinguishing gas when placed in proximity to an electric arc, means for establishing an arc within said chute, diverging arc horns disposed within said chute for providing terminals for said arc, a portion of said wall members adjacent said arc horns being lined with a magnetic material to strengthen the magnetic reaction for moving the arc laterally between the arc horns, and means for venting said chute in such manner that the gas evolved from said lining aids in the lateral movement of said arc between said arc horns during each circuit opening operation.

9. In a circuit interrupter, means for defining a narrow slot-like arc passage, said arc passage being closed at one end and vented at the other end, a pair of opposed arc terminal members within said passage, means for establishing an arc between said arc terminal members, portions of the inner walls of said arc passage adjacent said arc terminal members being lined with a magnetic material for strengthening the magnetic reaction for moving the arc laterally between said arc terminal members and substantially the remaining portions of the inner walls of said passage including a material which gives off a gas when acted upon by an arc to aid in moving and in extinguishing the arc.

10. In a circuit interrupter, means for defining a narrow slot-like arc passage, said arc passage being closed at one end and vented at the other end, a pair of contact members relatively movable from a closed to an open position for establishing an arc within said passage, each of said contact members having an arc horn movable therewith and between which said arc is adapted to be moved, portions of the inner walls of said passage adjacent said arc horns when in the open position being lined with a magnetic material for strengthening the magnetic reaction to move the arc laterally between said arc horns and substantially the remaining portions of the inner walls of said passage being lined with a material which gives off a gas when acted upon by an arc to aid in moving and in extinguishing the arc.

11. In a circuit interrupter, means including a pair of opposed wall members for defining a narrow slot-like arc passage, said passage being closed at one end and vented at the other end, a fixed contact within said passage adjacent the closed end, a cooperating contact movable to open and closed positions, an arc horn mounted on each contact, said arc horns being disposed in diverging relation with respect to each other, and a plate of magnetic material having the same general shape as said arc horns secured to the inner surface of each of said wall members adjacent said arc horns when the latter are in the open circuit position for causing the arc drawn between said contacts to be moved laterally between said diverging arc horns, at least the portion of the wall members between said plates of magnetic material being lined with a material which gives off a gas when acted upon by an arc to aid in moving and in extinguishing the arc.

12. In a high voltage circuit interrupter, means including a pair of opposed wall members for defining a confined arc passage of slot-like cross-section, said passage being closed at one end and open at the other end, means adjacent the closed end of said passage for drawing an arc therein, at least one of said wall members having a substantial portion thereof lined with a material which gives off a gas when acted upon by an arc to move said arc laterally toward the open end of said passage, said wall members being spaced apart a distance to cause the deionization of arcs of at least 300 volts per centimeter of arc length.

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