United States Patent

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[73] Assignee **General Electric Company**
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[54] **ARC CHUTE FOR AN ELECTRIC CIRCUIT BREAKER**
7 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **200/144,** 200/147, 200/149
[51] **Int. Cl.** **H01h 9/30,** H01h 33/00
[50] **Field of Search** 200/144, 144.3, 147, 148.3, 149.1

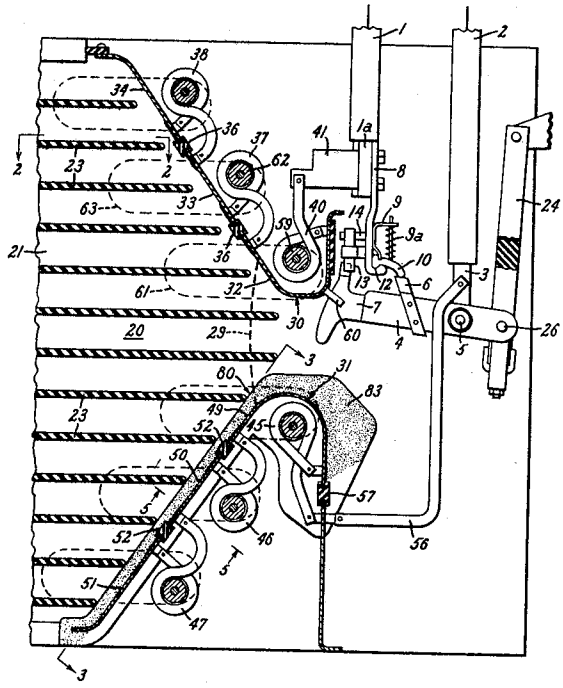
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1,915,969	6/1933	Barringer	200/144(.3)
2,366,485	1/1945	Brink et al.	200/144UX
2,645,693	7/1953	Cole et al.	200/144(.3)
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ABSTRACT: Discloses an arc chute having spaced sidewalls of a first insulating material and arc runners having most of their active surfaces of a refractory metal. Between one of the runners and the sidewalls are two face plates of a second insulating material, such as glass-bonded mica, that is characterized by low gas evolution and greater surface resistivity than said first material under high humidity conditions. The face-plate surfaces adjacent an arc are shielded from the arc by a thermally-sprayed coating of refractory ceramic insulating material on said surfaces.



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Fig. 1.

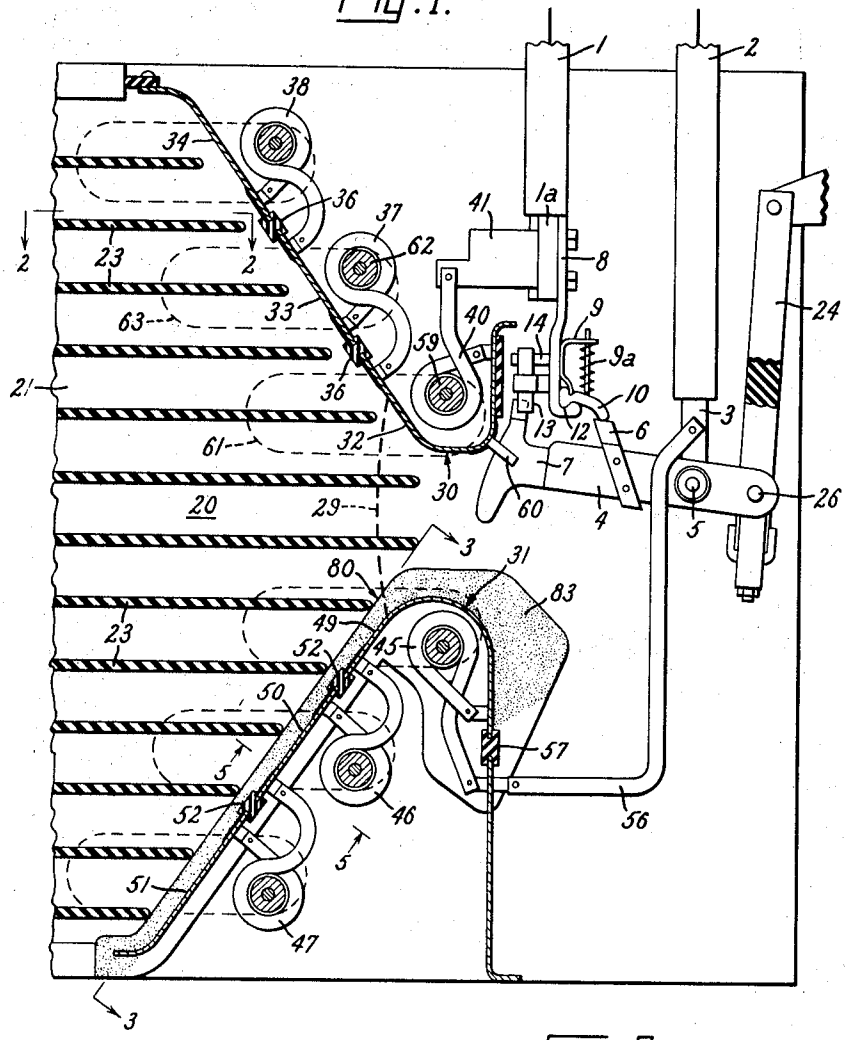


Fig. 3.

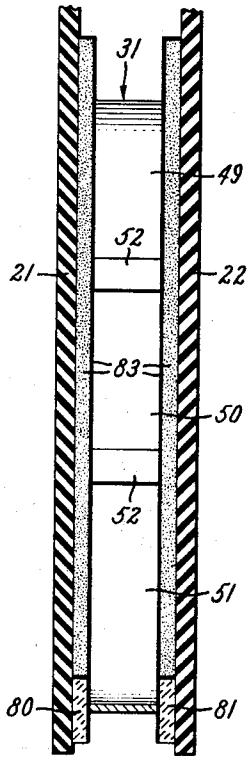


Fig. 2.

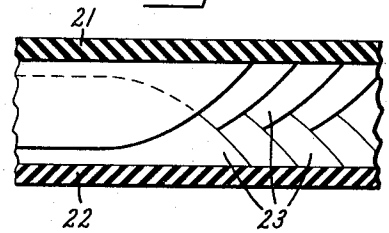


Fig. 5.

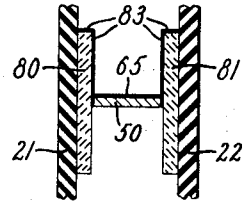
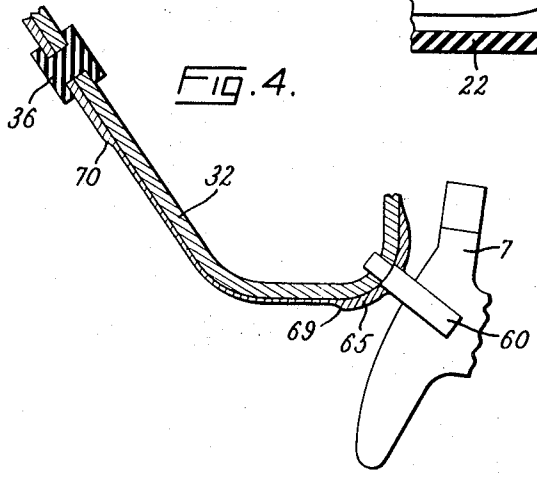


Fig. 4.



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ARC CHUTE FOR AN ELECTRIC CIRCUIT BREAKER

This invention relates to an arc chute for an electric circuit breaker and, more particularly, to an arc chute comprising metallic arc runners along which the terminals of the usual arc travel as the arc is driven into the chute.

In U.S. Pat. Nos. 2,366,485—Brink et al. and 2,704,381—Nelson, both assigned to the assignee of the present invention, there is disclosed an arc chute material made by reacting concentrated orthophosphoric acid and chrysotile asbestos. While this material has many properties which make it an excellent arc chute material, it has been found that its surface resistivity under high humidity conditions is not as high as might be desired. To avoid a dielectric breakdown along the arc chute surface under these high humidity conditions, it has been customary to provide, adjacent one of the arc runners and dielectrically in series with the phosphoric acid-asbestos material, face plates made of an insulating material having a high surface resistivity that is relatively unaffected by high humidity. The material customarily used for these face plates is a glass-bonded mica material, such as that sold under the trademarks Mycalex or Havalex.

In copending application S.N. 756,863—Bailey et al., assigned to the assignee of the present invention, there is shown and claimed an arc chute of the above type which can interrupt exceptionally high values of current. A plasma-arc - sprayed refractory metal coating on the runners of this arc chute makes it possible for this arc chute to interrupt higher values of current than were attainable without such refractory metal coating. Our studies of such chutes indicate, rather unexpectedly, that at these higher values of current, the glass-bonded mica face plates are imposing an upper limit on the amount of current that can be successfully interrupted.

Although glass-bonded mica has customarily been considered to be relatively nongas-evolving (see, for example, U.S. Pat. 2,761,934—Wood, lines 18—28, column 12) it appears that at these extreme high current levels, the arc will evolve sufficient gases from the glass-bonded mica to detrimentally affect the interrupting capacity. Of previously unappreciated significance with respect to this point is the fact that the gases evolved from the glass-bonded mica contain low ionization potential components such as sodium and potassium. Where there is no refractory metal coating on the arc runners, currents up to the maximum interrupting capacity of the circuit breaker either are not high enough to result in significant gas evolution from the glass-mica material or the effects of any such gas evolution from the glass-mica are dominated by the much more copious evolution of metal vapors from the runners. But at higher currents, with arc runners having a major portion of their surface of refractory metal, the gases evolved from the glass-mica do appear to be significant.

Accordingly, an object of my invention is to increase the current interrupting capacity of an arc chute that comprises (1) arc runners having a major portion of their surfaces of refractory metal and (2) face plates of glass-bonded mica or a similar material containing low ionization potential components.

Another object is to appreciably reduce the quantity of gases that will be evolved from such insulating face plates under extreme high current conditions, yet without impairing the ability of such face plates to maintain a high dielectric strength under conditions of high humidity and without significantly impairing the mechanical strength properties of the face plates.

In carrying out our invention in one form, we provide an arc chute comprising arc runners each having a major portion of its arc-running surface of a refractory metal. A pair of plates of low-gas-evolving insulating material are positioned on opposite sides of one of the runners between the runners and the adjacent insulating sidewalls of the arc chute. These plates are of glass-bonded mica or a similar insulating material that is characterized by (1) a high surface resistivity under conditions of high humidity as compared to the material of the arc chute's sidewalls and (2) the inclusion of ingredients which

decompose upon exposure to extreme high current arcs into low-ionization-potential metal vapors. The arc-exposed regions of these plates are coated with a thermally-sprayed coating of a refractory ceramic insulating material such as alumina. This coating acts as a shield between the arc and the base material of the plate which significantly reduces the amount of low-ionization-potential gases evolved from the base material.

For a better understanding of the invention, reference may be had to the following description taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a side elevational view, partly in section, showing an electric circuit breaker embodying one form of our invention.

FIG. **2** is a cross-sectional view taken along the line **2–2** of FIG. **1**.

FIG. **3** is a sectional view taken along the line **3–3** of FIG. **1**.

FIG. **4** is an enlarged view of a portion of FIG. **1**.

FIG. **5** is a sectional view along the line **5–5** of FIG. **1**.

The invention is illustrated in connection with a circuit breaker of the type shown and claimed in U.S. Pat. Nos. 2,901,579—Simpon and 3,050,062—Korte et al., assigned to the assignee of the present invention. Referring now to FIG. **1**, the circuit breaker shown therein comprises a pair of terminal bushings **1** and **2**, both of which are fixed in position relative to the supporting frame of the circuit breaker. The bushing **2** comprises a downwardly extending conductive stud **3** at the lower end of which a movable conductive switch blade **4** is mounted by means of a fixed pivot **5**. At its outer end, the blade **4** carries suitable circuit-controlling contacts such as a current-carrying contact **6** and an arcing contact **7**.

Bushing **1** comprises a conductive stud *1a* to which a downwardly extending conductive member **8** is electrically connected. Attached to this conductive member **8** is a curved contact-retaining member **9** which coacts with the member **8** to form a holding pocket for receiving the anchored ends of main current-carrying contact fingers **10**. These fingers **10** are pivotally mounted on a curved portion **12** of the conducting member **8** and are biased for limited rotative wiping movement in a closing direction by means of suitable compression springs *9a*. These compression springs *9a* provide for high-pressure circuit-closing engagement between the stationary current-carrying contact **10** and the movable current-carrying contact **6**.

The movable arcing contact **7** cooperates with a stationary arcing contact **13**, which is mechanically and electrically connected to the conducting member **8** by suitable clamping means **14**. The material of the arcing contacts **7** and **13** is capable of withstanding arcing and is also of a relatively high resistivity in comparison to the material of the current-carrying contacts **10** and **6**. Accordingly, when the switch blade **4** is in the closed position shown, most of the circuit current flows through the current-carrying contacts. It is only when the switch blade **4** is driven counterclockwise to open the breaker that the arcing contacts carry appreciable current. During each opening action, the current-carrying contacts first part, thereby diverting current through the arcing contacts which are still in engagement due to their extensive wipe. Thereafter, the arcing contacts part and draw a circuit interrupting arc which is driven into an arc chute **20** and there lengthened, cooled, and extinguished in a manner soon to be described.

For driving the switch blade **4** counterclockwise to effect circuit interruption, a reciprocable operating rod **24** pivotally joined to the switch blade at **26** is provided. When this operating rod is driven upwardly, it acts to move the switch blade counterclockwise to effect a circuit interrupting operation. The circuit can be reestablished simply by driving the operating rod downwardly to return the switch blade **4** in a clockwise direction to the closed position shown. The operating rod **24**, which is of insulating material, is actuated by means of a suitable conventional operating mechanism (not shown).

Referring now to FIGS. **1** and **2**, the arc chute assembly **20** comprises a pair of sidewalls **21** and **22** constructed of ap-

propriate arc-resistance insulating material. These sidewalls are clamped together in spaced-apart relationship by suitable means, not shown. Each sidewall preferably comprises ribs **23** projecting toward the other sidewall and arranged to mutually interleave with the corresponding projecting ribs on the other sidewall, thereby forming a sinuous or zigzag passage as viewed from the entrance end of the chute. As shown in FIG. **2**, these ribs taper toward the entrance of the chute and thereby provide a throat portion through which the arc first passes before entering the zigzag passage between the ribs **23**. Generally speaking, this construction is of the type disclosed in U.S. Pat. No. 2,293,513—Linde, assigned to the assignee of the present invention. A position of the arc as it moves into the chute is illustrated by the dotted line **29**.

For facilitating movement of the arc into the arc chute, a pair of conductive arc runners **30** and **31** are provided along the upper and lower edges of the chute. As shown in FIG. **1**, these runners **30** and **31** extend transversely to the path of the arc and in generally divergent relationship with respect to each other from the region in which the arc is initiated.

The upper arc runner **30** is made up of a plurality of segments **32, 33** and **34** disposed in end-to-end relationship, with the adjacent ends thereof separated by insulating spacers **36**. Electrically bridging the spacer **36** nearest the arc-initiation region is a magnetic blowout coil **37** having one terminal connected to runner segment **32** adjacent the spacer **36** and its other terminal connected to runner segment **33** immediately adjacent this same spacer **36**. The other spacers **36** is bridged by blow-out coil **38** connected between adjacent runner segments in a corresponding manner. The runner segment **32** located nearest the arc-initiation region is preferably of a generally U-shaped configuration and is electrically connected to the terminal stud *1a*. This electrical connection is through a conductive adapter **41** and an additional blow-out coil **40**, which has one terminal connected to the adapter **41** and its other terminal connected to the inner most end of runner segment **32**. Considering an electrical circuit which extends between the outermost runner segment **34** and the terminal conductor *1a*, it will be noted that the blowout coils **38, 37, 40** are connected in series-circuit relationship with each other as well as with the runner segments **32, 33, 34**.

The lower arc runner **31** is constructed in substantially the same manner as the upper arc runner **30**. In this respect, the lower arc runner comprises a plurality of elongated segments **49, 50** and **51** disposed in end-to-end relationship and separated by insulating spacers **52**. Spacers **52** are respectively electrically bridged by blow-out coils **46** and **47** connected between the adjacent runner segments. The runner segment **49** nearest the arc-initiation region is of a U-shaped configuration and is electrically connected to the terminal conductor **3** of the circuit breaker through blow out coil **45**. In this regard, a conductive strap **56** is electrically connected between the terminal conductor **3** and one terminal of blowout coil **45**, whereas the other terminal of the blowout coil **45** is connected to the innermost end of the runner segment **49**. An insulating spacer **57** is provided at the lower end of runner segment **49** to prevent the coil **45** from being short-circuited by the runner structure located across its terminals.

The purpose of the above-described blowout coils is to accelerate the movement of the arc along the runners into the interior of the chute. In this regard, each blow-out coil is provided with a centrally located core insulated from the coil and attached to pole pieces mounted on the outer surfaces of the sidewalls of the chute. For example, the coil **40** has a core **59** attached to pole pieces such as **61** shown by dotted lines in FIG. **1**. The coil **37** has a core **62** attached to similar pole pieces **63**. In a like manner, all of the other blowout coils have similar cores and pole pieces, only some of which are shown. When a particular coil is energized, its pole pieces provide a magnetic field transverse to the arc path, and this magnetic field reacts with the magnetic field surrounding the arc to produce a resultant force which drives the arc at high speed along the runners into the interior of the chute. The general manner in which these magnetic fields react to produce the arc-motivating force is well known and therefore will not be described in further detail.

When the switch blade **4** is driven counterclockwise to open the breaker, an interrupting arc is established between the arcing contacts **13** and **7** as soon as those contacts part. The upper terminal of this arc quickly transfers to the runner segment **32**, thereby connecting the blowout coil **40** in series with the arc. The energized coil immediately creates a magnetic effect which begins to drive the upper arc terminal along the upper runner **30** toward the interior of the chute. As the upper arc terminal moves along the runner **30** past the insulating spacers **36**, it acts to successively insert the connected blowout coils in series with the arc, thereby progressively increasing the magnetic forces tending to drive the arc into the chute.

In the meantime, the movable switch blade **4** has swung rapidly away from the stationary contact **13**. When the switch blade **4** moves downward into proximity with the runner segment **49** of the lower arc runner, the lower terminal of the arc transfers to the runner segment **49**, thus inserting the lower blowout coil **45** in series with the arc. The energized coil **45** immediately creates a magnetic blowout effect which drives the lower terminal of the arc along the lower runner **31** toward the interior of the chute. When the lower terminal of the arc passes the first insulating spacer **52**, it acts to insert the next blowout coil **46** in series with the arc and the first blowout coil **45** thereby providing increased magnetic force for driving the arc into the chute. As the arc moves into the chute, it becomes elongated and cooled by the projecting ribs **23**, and thus acts to quickly deionize and thereby extinguish the arc so as to interrupt the circuit. Typically, the arc terminals move to the end of the runners before interruption is completed.

To facilitate transfer of the upper arc terminal from the arcing contact **13** to the first runner segment **32**, a pair of projecting electrodes **60** are provided at opposite sides of the movable arcing contact **7**. Each of these electrodes **60** is made of an arc-resistant material such as tungsten impregnated with copper or silver. The arc that is drawn between contacts **7** and **13** upon arc separation strikes one of the electrodes, causing its upper terminal to attach thereto; and immediately thereafter the upper terminal moves toward the base of the electrode onto the runner segment **32**.

On opposite sides of the lower arc runner **31** are a pair of face plates **80** and **81** of a glass-bonded mica material, such as that sold under the trademark Mycalex. This material has an exceptionally high surface resistivity, which it is able to maintain despite conditions of high humidity in the surrounding air. As shown in FIG. **3**, the face plates **80** and **81** are sandwiched between the lateral edges of the arc runner **31** and the sidewalls **21** and **22**, respectively. These face plates extend along the runner **31** over substantially the entire length of the runner that is exposed to the arc.

The material of the sidewalls **21** and **22** and ribs **23** is preferably a reaction product of asbestos and orthophosphoric acid (such as disclosed in U.S. Pat. 2,366,845—Brink and Arone, assigned to the assignee of the present invention) and containing a suitable inert filler such as zircon. This material, while excellent for arc-extinguishing purposes, has a lower surface resistivity than the Mycalex material, particularly under conditions of high humidity; and the arc chute must rely upon the Mycalex face plates to assure against a dielectric breakdown along its walls in the region between the arc runners **30** and **31** under high humidity conditions.

Each of the metal runner segments **32, 33, 34** and **49, 50, 51** is preferably of brass but has its surface that is exposed to the arc completely coated with a layer of refractory metal, e.g., tungsten, applied by plasma-arc spraying. This latter feature is disclosed and claimed in the aforesaid Bailey et al. application, S.N. 756,863. FIG. **4** shows the layer of refractory metal in more detail at **65**. This layer is preferably of greater thickness in regions such as **69** and **70** where there is greater exposure to the arc. The presence of this thermally-sprayed

layer of refractory metal on the runners raises the current interrupting capacity of the circuit breaker to a level appreciably higher than is attainable without the refractory metal layer or with small refractory metal pads brazed to the runners at a few points thereon.

We have found that we can raise the current interrupting capacity of this arc chute even further by coating the glass-bonded mica face plates **80** and **81** with a coating of a ceramic material such as alumina. This coating is indicated at **83** in FIGS. **1**, **3**, and **5**. In a preferred form of the invention, we apply this coating by the plasma-arc spraying process described in copending application S.N. 731,466, Bailey et al. filed May 23, 1968. The alumina coating is not applied to the ribs **23** or sidewall **21**, **22**. However, all portions of the glass-bonded mica face plates **80** and **81** that are exposed to the arc are so coated.

A cross-sectional photomicrograph of the coating **83** shows that the coating is laminar in structure and is constituted by flattened interlocking particles of alumina.

Studies have been made to determine the reasons why the alumina coating increases the current interrupting capacity of the arc chute. It appears from these studies that, although the bare Mycalex material will evolve relatively little gas when exposed to a high current arc, if the arc is of extreme high current, some of the Mycalex will decompose into vapors containing sodium and potassium. These vapors have a relatively low ionization potential, and any which are not condensed at current zero can be ionized by the high voltages then appearing to initiate a dielectric breakdown. By applying a relatively thick alumina coating to the surface of the face plates, we can greatly reduce the extent to which the Mycalex material is heated and vaporized by the extreme high current arc, thus substantially eliminating the sodium- and potassium-containing vapors. In a preferred form of the invention the alumina coating is 20 to 25 mils in thickness.

The refractory metal coating on the arc runners **30** and **31** plays an important role in enabling the alumina on the face plates **80** and **81** to make its contribution to increased interrupting capacity. At currents up to the highest values that can be interrupted by the illustrated arc chute without the refractory metal coating on its runners, the glass-bonded mica, even if uncoated and exposed to the arc, will evolve so little glass that its presence does not appear to detract from the current interrupting capacity of the chute. The refractory metal coating on the arc runners enables higher currents to be interrupted by the arc chute, i.e., currents above 25,000 amperes, r.m.s.; and it is only when such higher currents are being interrupted that the glass-bonded mica, if uncoated and exposed to the arc, would evolve a quantity of vapors sufficient to detract from interrupting ability. It is under these particular high-current conditions that the alumina coating acts to effectively prevent vaporization of the glass-bonded mica into low ionization potential vapors.

Although we have described our invention particularly in connection with a base material containing sodium and potassium compounds, it is to be understood that, in its broader aspects, the invention is intended to apply to base materials containing only one of these compounds or some other low-ionization-potential ingredient. By low-ionization potential, we mean a first ionization potential under 5.5 electron volts.

An additional advantage of using glass-bonded mica material for the face plates **80** and **81** is that this material has exceptional mechanical properties that facilitate fabrication of the face plates and their assembly into the chute. More specifically, this material has greater mechanical strength, toughness, and flexibility, and is more readily machined than most ceramics. The plasma-arc sprayed alumina coating **83** that we apply to the glass bonded mica does not significantly detract from these very desirable properties of the glass-bonded mica but does significantly improve the performance of the glass-bonded mica under extreme high-current arcing conditions as was explained hereinabove. The plasma-arc sprayed alumina coating has a surface resistivity much higher than the material of the arc-chute sidewalls, and this high surface resistivity is maintained under high humidity conditions, thus enabling the coated face plates to function in the same way as the bare face plates in preventing dielectric breakdowns. Because the glass-bonded mica evolves relatively little gas under high-current conditions, particularly when it is shielded by the alumina coating, the alumina coating is able to remain tightly bonded thereto despite exposure to high-current arcing. This would not be the case with a base material such as the phosphoasbestos material of the arc-chute sidewalls, which evolves much greater quantities of gas when exposed to the temperatures produced by a high-current arc. Under high-current arcing conditions, an alumina coating on such a base material would be forced off by the pressures developed underneath it by gas evolution from the base material.

While we have shown and described a particular embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the invention in its broader aspects; and we, therefore, intend herein to cover all such changes and modifications as fall within the true spirit and scope of our invention.

We claim:

1. An electric circuit breaker comprising an arc chute into which an arc is adapted to be driven for the purpose of extinguishing the arc, said arc chute comprising:

a. a pair of spaced-apart sidewalls of a first insulating material extending along the length of said arc;

b. a pair of conductive arc runners spaced apart within said chute for defining paths along which the terminals of said arc travel as the arc is driven into said chute;

c. said runners having refractory metal surfaces along a major portion of the paths traveled by said arc terminals during circuit interruption;

d. a pair of face plates of low-gas-evolving insulating material positioned on opposite sides of one of said runners between said runners and said insulating sidewalls, said plates being of a second insulating material that has a much greater surface resistivity under humid conditions than the material of said insulating sidewalls;

e. said second insulating material containing one or more low ionization potential metallic components that will vaporize at temperatures produced at the surface of said plates by arcs on said one runner carrying high currents within the current interrupting rating of said circuit breaker, assuming said plate surface was bare; and

f. and means for shielding the surfaces of said plates adjacent said one runner from said arcs comprising a thermally sprayed coating of refractory ceramic insulating material on said plate surfaces.

2. The circuit breaker of claim **1** in which said refractory metal surface is constituted by thermally sprayed refractory metal.

3. The circuit breaker of claim **1** in which said second insulating material is a glass-bonded mica material.

4. The circuit breaker of claim **1** in which said second insulating material is a glass-bonded mica material and said refractory ceramic insulating material comprises alumina.

5. The circuit breaker of claim **1** in which said first insulating material is a phosphoric acid-asbestos material, said second insulating material is a glass-bonded mica material, and said refractory ceramic insulating material comprises alumina.

6. The circuit breaker of claim **1** in which the interrupting rating of said arc chute is higher than 25,000 amperes r.m.s.

7. The circuit breaker of claim **4** in which said coating of alumina has a thickness of at least 20 mils.