Dec. 28, 1943. L. S. WALLE 2,337,949

CIRCUIT BREAKER

Filed May 29, 1942

Fig. 1.

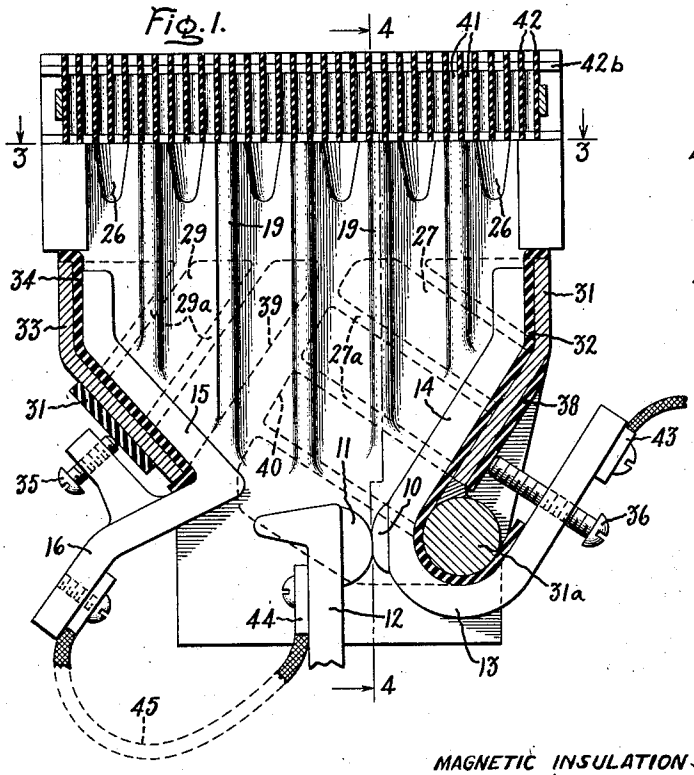


Fig. 2.

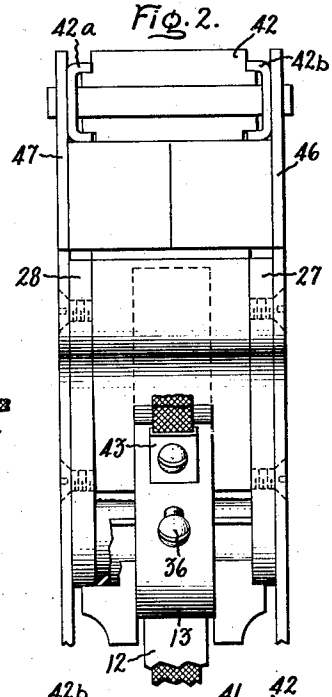
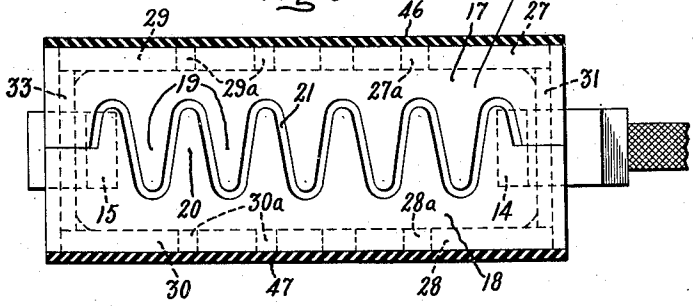


Fig. 3.



MAGNETIC INSULATION

Fig. 4.

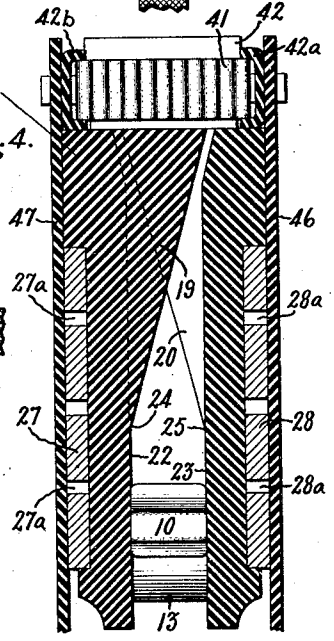
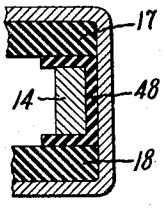


Fig. 5.



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UNITED STATES PATENT OFFICE

2,337,949

CIRCUIT BREAKER

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Application May 29, 1942, Serial No. 444,972

16 Claims. (Cl. 200—147)

My invention relates to circuit breakers, more particularly to arc extinguishers for circuit breakers, and has for its object a simple, effective and low cost device for extinguishing an arc.

In carrying out my invention in one form, I form the arc extinguisher device mainly from a material which is an electrical insulator and which also has the characteristic of being a conductor of magnetic flux. This material is preferably a basically inorganic one that can be molded in the desired form and may, for example, be formed of a mixture of iron oxide, asbestos powder and phosphoric acid, this mixture being molded by subjecting it to a high pressure and heat.

This magnetic flux permeable material forms a path for the magnetic flux generated by the current in the arc and produces a more intense magnetic field around the arc whereby the arc is moved electromagnetically into the device thereby to be lengthened, reduced in section, cooled and thereby extinguished. To further lengthen the arc, the extinguisher device is formed to provide a plurality of substantially parallel walls which are substantially perpendicular to the arc.

For a more complete understanding of my invention, reference should be had to the accompanying drawing in which Fig. 1 is a side elevation view, partly in section, of an arc extinguisher device embodying my invention; Fig. 2 is an end view of the device shown in Fig. 1; Fig. 3 is a sectional view along the line 3—3 of Fig. 1 looking in the direction of the arrows but showing a complete device; Fig. 4 is a sectional view along the line 4—4 of Fig. 1 looking in the direction of the arrows but showing a complete device; while Fig. 5 is a fragmentary view in section of a modified form of my invention.

Referring to the drawing, I have shown my invention in one form as applied to a stationary contact 10 with which cooperates a movable contact 11, the movable contact being commonly mounted on the end of an arm 12 which is mounted for pivotal movement so that the contact 11 is movable by manual or other means (not shown) toward the left, as seen in Fig. 1, about this pivot to an open circuit position. The contact 10 is mounted adjacent the lower end of a U-shaped member 13 made of electrically conducting material, the inner arm 14 of which forms a runner for movement of the arc upward, as seen in Fig. 1.

Suitably spaced horizontally from the contact 10 is a second arc runner member 15 made of electrically conducting material, such as copper, having a lower portion 16 extending at an acute angle toward the left so as to be just above the movable contact 11 when it moves to its open circuit position. These two arc runners 14 and 15, as shown, diverge apart in an upward direction so that as the arc travels upward on these two members it is elongated. Preferably, the contacts and arc extinguisher will be mounted in the upright position shown in Fig. 1.

The arc extinguisher, as shown, is of the type described and claimed in Patent No. 2,306,204, issued on December 22, 1942, to Eugene W. Boehne. It is molded in the form of two plates or members 17 and 18 which are positioned on opposite sides of the path of movement of said movable contact and are formed with complementary projections or ridges thereby to provide a plurality of substantially parallel walls. As shown, the member 17 is provided with a plurality of equally spaced projections or ridges 19 which extend substantially vertically, as seen in Fig. 1, and which are narrower at their tops than at their bases. Likewise, the member 18 is provided with a plurality of projections or ridges 20 which are identical in size and spacing with the projections 19 but are complementary with the projections 19 so that the projections, when the two blocks are put together as seen in Fig. 3, are interleaved or set between each other alternately. Also, the members are so formed that the projections 19 and 20 are spaced apart, as seen in Fig. 3, so as to form a continuous narrow slot 21 of substantially uniform width, as seen in Fig. 3, at the upper ends of the members 17 and 18. Thus, the projections 19 and 20 form a plurality of substantially parallel spaced walls extending substantially at right angles to the path of movement of the movable contact 11.

These projections 19 and 20 are tapered downward, i. e., become shallower, from the upper end downward, as shown in Fig. 4. As shown in this figure, the tops of the projections or right- and left-hand edges are straight and meet with the lower substantially flat inner walls 22 and 23 at points 24 and 25 just above the arc runners 14 and 15. Between the bottoms of the projections are continuations upward of the flat surfaces 22 and 23. At the upper ends of the projections, however, the material between the projections is cut away to form recesses 26 in each of the members 17 and 18, these recesses providing for a greater height of the opposite projections at their upper ends.

Thus, it will be seen that as the movable contact 11 moves toward the left, the arc at first

strikes directly between the two contacts and is not interfered with by the projections 19 and 20. As the arc travels upward, however, it is forced to pass more and more between the projections whereby the arc is elongated and restricted in cross section. Thus, any portion of the arc that exists at the top of the members 17 and 18 must take the very much elongated and restricted path of the slot 21 shown in Fig. 3.

For the purpose of producing an increased magnetic field in the arc space between the plates for assisting electromagnetically the rapid movement of the arc upward into the elongated and restricted path provided by the slot 21, I make the members 17 and 18 from a homogeneous material having substantially uniform electrically insulating and magnetic characteristics throughout the members. This material, while still electrically insulating, is magnetic to a pronounced extent. In other words, the members 17 and 18 have a relatively high permeability as compared with the permeability of air and other well known electrical insulators. I preferably make the members from a mixture of magnetic material and electrically insulating material of the type described and claimed in applications Serial Nos. 423,518 and 507,016, filed by Edwin H. Brink and Nicholas F. Arone on December 18, 1941, and October 20, 1943, respectively, both assigned to the same assignee as this invention. Preferably I use a mixture by weight of 3 parts powdered iron oxide (FE_3O_4) and 1 part asbestos powder, with 15 cubic centimeters of 75 per cent phosphoric acid (HP_3O_4) for each 100 grams of the mixture. These materials are thoroughly mixed together, heated to a temperature of 200° F., and subjected at that temperature to a pressure of about 3,000 pounds per square inch in forming the members or blocks 17 and 18. In a typical circuit breaker the permeability of the material of the blocks was found to be about seventy, i. e., seventy times the permeability of air. This circuit breaker interrupted successfully a current of over 10,000 amperes at 600 volts A.-C.

Preferably, in the aforesaid mixture I use an asbestos powder consisting by weight of:

	Per cent
MgO	33.30
SiO_2	40.92
Fe_2O_3	8.70
Al_2O_3	5.18
H_2O	11.30

This asbestos, while containing 8.7% of iron oxide, does not, I have found, show any trace of magnetic attraction even when molded into an article.

The molded material manufactured as I have described, in a typical case, had for a cubic centimeter sample, ohmic resistances as follows: at 1,000 volts applied to opposite sides of the sample an infinite resistance; at 1,200 volts applied, 240,000 ohms resistance; at 1,500 volts applied, 80,000 ohms resistance. The composite material thus has a negative temperature coefficient, the leakage current through it heating the material and lowering its resistance. When the material is cooled to its original temperature, its original insulation resistance values are restored.

A destructive or appreciable current through the material of the arc chute may therefore be defined as a current of a value, such as in excess of 5 milliamperes a square centimeter, which generates more heat than is radiated from the chute members with consequent eventual decrease of the resistance of the material to a point that the chute and breaker are destroyed.

Preferably, after the arc chute members 17 and 18 have been molded and finished as to form, they are subjected to an additional baking operation for a period of twelve hours at a temperature of 110° C. This baking operation improves the dielectric characteristics of the material of the arc chute members.

If desired to assure a greater uniformity in the pressure applied to the mixture, the blocks may be molded with more or less uniform rectangular cross sections and then machined to provide the various grooves and projections.

In order to still further reduce the reluctance of the magnetic flux path, I provide a pair of magnetic soft iron plates 27 and 28 on the outer sides of the plates 17 and 18 and on opposite sides of the contact 10 and the arc runner arm 14. Also, I provide a pair of magnetic iron plates 29 and 30 on the outside of the plates and on opposite sides of the arc runner 15. These plates 29 and 30, as shown, are preferably set in recesses provided for them in the plates and have substantially their entire inner surfaces in engagement with the plates 17 and 18.

The pair of plates 27 and 28 are electromagnetically joined together at their outer ends by a plate 31 of magnet iron inserted between the outer ends of the plates and in engagement with the plates so as to be in good magnetic flux conducting relation with them. This plate 31 extends across the outer ends of the blocks and it is separated from the arc runner 14 by a layer of suitable electrically insulating material 32. As shown in the drawing, the arc runners 14 and 15 have the same width, i. e., dimension as seen in Fig. 4, as the distance between the blocks at the points where the arc runners are secured.

Also, a bar 31*a*, made of magnet iron, lies in the curve of the conductor member 13 and joins magnetically together at this point the two plates 27 and 28. It will be understood that the conductor 13 forms a half turn blow-out coil around the bar 31*a* for the generation of magnetic flux.

A second cross plate 33 made of magnet iron is provided for joining together the ends of the plates 29 and 30, this member 33 being separated from the arc runner 15 by a layer of electrically insulating material 34. The two plates 31 and 33 are held in position against the ends of the blocks by means of screws 35 and 36 mounted in extensions on the members 13 and 16, layers of electrically insulating material 37 and 38 being provided between the screws and the members 33 and 31.

As seen in Fig. 1, the adjacent spaced ends 39 and 40 of the iron plates 29 and 27 are formed so as to extend at an acute angle with the vertical, the two ends being substantially parallel with each other. The adjacent ends of the plates 30 and 28 are likewise formed to extend at an angle with the vertical. Also, the plates 27 and 28 are wide enough at their bases or lower ends, as seen in Fig. 1, so as to slightly overlap the lower end of the arc runner 15 whereby these two plates form part of the magnetic flux path of the entire arc at the time that the arc strikes from the lower end of the runner 15.

In order to reduce the undesirable effects of the magnetic flux induced in the plates 27 to 30, inclusive, they are provided with slots 27*a* to 30*a*, as shown in the drawing, the slots 27*a* and 28*a* extending substantially at right angles with the arc runner 14 and the slots 29*a* and 30*a* ex-

tending substantially at right angles with the arc runner 15.

I also provide at the top of the blocks 17 and 18 an arc cooler grill of the type described and claimed in Patent No. 2,293,513, issued on August 18,1942 to Leonard J. Linde comprising a plurality of vertically corrugated magnetic metal, such as iron, sheets or strips 41 which strips are electrically insulated from each other by strips 42 of electrically insulating material such as mica or fiber. Besides cooling the arc and accelerating the movement of the arc, there iron sheets or strips serve to effect a nearly uniform distribution of the arc and gases across the blocks, i. e., from one end of the slot 21 to the other. By spacing the insulating strips 42 farther apart toward the left side of the chute, as seen in Fig. 1, and using deeper upright corrugations in the metal strips, a nearly uniform spread of the arc and gases is obtained resulting in efficient cooling.

The metal strips 41 and the insulating strips 42 extend crosswise of the members 17 and 18, as shown in the drawing. They are held at their ends by U-shaped supporting members 42*a* and 42*b* into which their ends are inserted. The insulating strips 42 are wider than the metal strips in a vertical direction, as viewed in the drawing, and project above the metal strips at both the top and the bottom. The lower edges of the strips 42 rest on the upper plane surfaces of the chute members 17 and 18, and fit tightly on the upper surfaces of the chute members.

It will be observed that the strength of the magnetic field is governed by the distance between the blocks 17 and 18 since the blocks are made of a magnetic flux conducting material, instead of by the much greater distance between the pairs of plates 27, 28 and 29, 30. Thus as the arc rises, as seen in Fig. 1, and the distance between the blocks decreases, the air gap at that point, i. e., the distance between the blocks 17 and 18, correspondingly decreases with a corresponding increase in magnetic flux density for the propulsion of the arc upward into the narrow slot 21. In a typical device the slot 21 at the top of the chute was only $\frac{1}{32}$ of an inch wide, this being the air gap at that point.

The magnetic field is increased by the half turn of the U-shaped member 13 to the end of which one terminal 43 of the electric circuit is connected. This connection of course leads to the stationary contact 10. Connections (not shown) are established between the opposite terminal of the electric circuit and the contact area 12 and movable contact 11. Also, an electrical connection 44 and flexible conductor 45 connect electrically the contact arm 12 to the lower end of the bar 16 so that the arc when it strikes to the runner 15 will be in the electric circuit of the circuit breaker. Electrically insulating supporting plates 46 and 47 are provided on opposite sides of the device by means of which it may be secured to the base of the circuit breaker.

Thus it will be observed that the two arc chute members 17 and 18 serve as inner pole pieces for the pairs of magnet plates 27, 28 and 29, 30. The amount of magnetic flux that is generated is in inverse proportion to the reluctance of the magnetic path which consists, for example, at one end of the device of the iron plates 27, 28 and 31, the two chute members 17 and 18 and the air gap between the chute members. The reluctance of this path is very small except for the air gap, but the air gap at the top is very short, as short as $\frac{1}{32}$ of an inch in a typical device. Therefore, a large amount of magnetic flux is produced in each magnetic circuit at the ends of the chute by a small expenditure of electric energy. The magnetic flux is produced by the current in the half turn of the U-shaped member 13 and after the contacts have separated, by the current in the arc runners or arcing horns 14 and 15.

The magnitude of the force pushing upward on the current carrying arc, as with all current carrying conductors, is in proportion to the amount of the magnetic flux the arc includes. The arc moves in a direction to embrace the greatest amount of flux, consequently upward as seen in the drawing. The arc keeps on including more and more flux regardless of its figuration until the very top edge of the chute is reached. The arc is restrained somewhat, of course, by the narrow passage of the chute.

It will be understood that by the use of material of higher electrically insulating value at crucial points, a magnetic insulating material can be used for the chute members 17 and 18 having a lower electrical resistance than the preferred material described hereinbefore. This material would have a composition giving it a correspondingly higher magnetic permeability; for example, it may have an increased proportion of iron oxide. For example, as shown in Fig. 5, the arc runner member 14 is surrounded on three sides by an electrically insulating channel 48 made of a suitable electrically insulating material such as fibre or asbestos. This channel 48 electrically insulates the arc runner from the chute members 17 and 18 so that these members can be made of a material having a higher magnetic permeability and lower resistance.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made, and I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The combintion in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit between said contacts, arc chute members on opposite sides of the path of movement of said movable contact made of a material which is electrically insulating to cause an arc between said contacts to pass between said members and magnetic to provide an increased magnetic field thereby to accelerate the movement of the arc between said members, and a plurality of sheets of magnetic mtaerial adjacent the edges of said chute members toward which the arc moves extending transversely with respect to the arc for further accelerating the arc movement.

2. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit between said contacts, and arc chute members on opposite sides of the path of movement of said movable contact made of a mixture of electrically insulating and magnetic materials which is electrically insulating to prevent the passage of an appreciable electric current therethrough and produce an arc between said contacts when said contacts are separated and which has many times the magnetic permeability of air thereby to accelerate the movement of the arc between said members.

3. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit between said contacts, and arc chute members on opposite sides of the path of movement of said movable contact made of a mixture of iron oxide and a powdered basically inorganic electrically insulating material in proportions such that said members are electrically insulating to cause an arc between said contacts to pass between said members and magnetic to provide an increased magnetic field thereby to accelerate the movement of the arc between said members.

4. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit between said contacts, and arc chute members on opposite sides of the path of movement of said movable contact provided with a plurality of spaced walls extending at right angles to the path of movement of said movable contact, said walls being made of a mixture of electrically insulating and magnetic materials which is electrically insulating to prevent the passage of an appreciable current therethrough and produce an arc between said contacts when said contacts are separated and magnetic to provide an increased magnetic field thereby to accelerate the movement of the arc between said walls.

5. The combination in a circuit breaker of a stationary contact, a cooperating movable contact having a predetermined path of movement, a pair of complementary spaced members constituting arc extinguishing members mounted on opposite sides of the path of movement of said movable contact providing a plurality of spaced apart substantially parallel walls substantially perpendicular to said path of movement, said members being made of an electrically insulating material having many times the magnetic permeability of air thereby to provide an increased magnetic field by the current in an arc between said contacts to force the arc between said spaced members, and a plurality of sheets of magnetic material adjacent those edges of said walls toward which the arc moves and extending transversely with respect to the arc for further accelerating the movement of the arc.

6. The combination in a circuit breaker of a stationary contact, a cooperating movable contact having a predetermined path of movement, a pair of plates forming an arc chute on opposite sides of the path of movement of said movable contact, a plurality of parallel ridges on the adjacent sides of said plates with the ridges on one plate interleaved with the ridges of the other plate and uniformly spaced with respect thereto and said ridges beginning at points adjacent said arc runners and gradually increasing in height to the upper extremities of said plates so that an arc between said runners is increasingly elongated in passing between said ridges as it moves upward between said plates, said plates being made of a mixture of electrically insulating and magnetic materials which is electrically insulating to prevent the passage of an appreciable current therethrough and magnetic to provide an increased magnetic field for acceleration of the movement of the arc between said plates.

7. The combination in a circuit breaker of a pair of spaced apart upwardly diverging arc runner members, a stationary contact on the lower end of one of said runner members, a cooperating movable contact having a predetermined path of movement extending under the other of said runner members, a pair of plates forming an arc chute on opposite sides of said runner members made of a mixture of powdered electrically insulating and magnetic materials having many times the magnetic permeability of air, a plurality of parallel ridges on the adjacent sides of said plates with the ridges on one plate interleaved with the ridges of the other plate and uniformly spaced with respect thereto and said ridges beginning at points adjacent said arc runners and gradually increasing in height to the upper extremities of said plates so that an arc between said runners is increasingly elongated in passing between said ridges as it moves upward between said plates, and a pair of plates of magnetic metal forming pole pieces on the exterior of said insulating plates in direct engagement with said plates and on opposite sides of each of said arc runners.

8. The combination in a circuit breaker of a stationary contact, a cooperating movable contact having a predetermined path of movement, a pair of complementary spaced members constituting arc extinguishing means mounted on opposite sides of the path of movement of said movable contact providing a plurality of spaced apart plates substantially perpendicular to said path of movement, said members being made of a mixture of powdered electrically insulating and magnetic materials having many times the magnetic permeability of air thereby to provide an increased magnetic field caused by the current in an arc between said contacts whereby the arc is forced by said field between said spaced members and thereby elongated, a pair of plates of magnetic metal on the exterior of said members in direct engagement with said members on opposite sides of said stationary contact, and a member of magnetic metal on the side of said stationary contact opposite said movable contact forming a magnetic path of high permeability between said plates, said plates and said connecting member forming a path of high magnetic permeability for magnetic flux set up by the current in an arc between said contacts.

9. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit between said contacts, arc chute members made of electrically insulating material on opposite sides of the path of movement of said movable contact, a pair of arc runners between said chute members associated respectively with said contacts, a U-shaped member made of magnetic material extending around at least one of said arc runners and being substantially coextensive lengthwise with said one arc runner and having its sides on the outside of said arc chute members and projecting beyond said one arc runner on opposite sides of the path of an arc between said arc runners, a layer of electrically insulating material between said U-shaped member and said one arc runner, said U-shaped member having a magnetic flux induced therein solely by the current in an arc between said arc runners, and a plurality of sheets of magnetic material adjacent edges of said chute members toward which the arc moves extending transversely with respect to the arc for further accelerating the arc movement.

10. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit between said contacts, arc chute members made of electrically insulating material on opposite sides of the path of movement of said movable contact, arc run-

ners between said chute members, a U-shaped member made of iron extending around each of said arc runners, each of said arc runners being substantially coextensive with the length of its said arc runner and having its sides on the outside of said arc chute members and projecting beyond its said arc runner on opposite sides of the path of an arc between said arc runners, a layer of electrically insulating material between each of said arc runners and its associated U-shaped member, and a plurality of sheets of magnetic material adjacent edges of said chute members toward which the arc moves extending transversely with respect to the arc for further accelerating the arc movement.

11. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit between said contacts, arc chute members made of electrically insulating material on opposite sides of the path of movement of said movable contact, arc runners between said chute members, a U-shaped member made of magnetic material extending around at least one of said arc runners substantially coextensive with the length of said one arc runner having its sides on the outside of said arc chute members and projecting beyond said one arc runner on opposite sides of the path of an arc between said arc runners, a layer of electrically insulating material between said one arc runner and said U-shaped member, a blow-out coil in the electric circuit between said contacts, a core member made of magnetic material encircled by said blow-out coil, and pole pieces of magnetic material on opposite ends of said core member extending outside of said arc chute members on opposite sides of the path of movement of said movable contact.

12. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit between said contacts, an arc runner member made of electrically conducting material extending upward from said stationary contact, a second arc runner spaced from said first arc runner extending upward in diverging relation with respect to said first arc runner, an electrical connection between said second arc runner and said movable contact, said second arc runner having its lower end in closely spaced relation with said movable contact when said movable contact is in its open circuit position so that an arc between said contacts rises along said arc runners, arc chute members made of electrically insulating material on opposite sides of said contacts and said arc runners, a pair of plates made of magnetic material on opposite sides of each of said arc runners and outside of said arc chute members, said plates being substantially coextensive with the length of each of said arc runners and extending beyond each of said arc runners on opposite sides of an arc between said arc runners, and a length of magnetic material on the outside of each of said arc runners joining together its pair of plates, a layer of electrically insulating material between each of said lengths and its arc runner, said pairs of plates acting by reason of the flux induced in said plates by the current in an arc between said arc runners to force the arc upward along said arc runners and between said arc chute members.

13. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit between said contacts, a pair of spaced apart arc chute members made of electrically insulating material on opposite sides of the path of movement of said movable contact, said members comprising walls converging toward each other in the direction of arc travel, said walls being made of a mixture of basically inorganic electrically insulating material and a small proportion of magnetic material to make said walls magnetic as compared with the air thereby to accelerate the movement of the arc between said converging walls.

14. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit through said contacts, and arc chute members on opposite sides of the path of movement of said movable contact at least one of which is made of a mixture of electrically insulating material and magnetic material having substantially uniform electrically insulating characteristics which are high enough to prevent the flow through said members of substantial currents at the voltage between said contacts and having substantially uniform magnetic characteristics which are high enough to accelerate the movement of an arc drawn between said contacts.

15. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit through said contacts, a pair of arc chute plates on opposite sides of the path of movement of said movable contact, each of said plates being in one piece made of a mixture of powdered electrically insulating material and powdered magnetic material in such proportions that said plates have a high resistivity to prevent the flow through them of substantial currents at the voltage between said contacts and are magnetic to accelerate the movement between them of an arc from one of said contacts to the other, a pair of plates of magnetic metal on the exterior of said arc chute plates in direct engagement throughout substantially their entire surfaces respectively with said arc chute plates, and a magnetic metal plate across one of the ends of said arc chute plates joining said first two metal plates.

16. The combination in a circuit breaker of a pair of contacts at least one of which is movable to close and open an electric circuit through said contacts, a pair of arc chute plates on opposite sides of the path of movement of said movable contact, each of said plates being in one piece made of a mixture of electrically insulating material and magnetic material in such proportions that said plates have a high resistivity to prevent the flow through them of substantial currents at the voltage between said contacts and are magnetic to accelerate the movement between them of an arc from one of said contacts to the other, and a plurality of spaced sheets of magnetic metal adjacent edges of said plates remote from said contacts extending transversely with respect to said plates for further accelerating the movement of an arc between said plates.

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