

April 13, 1965

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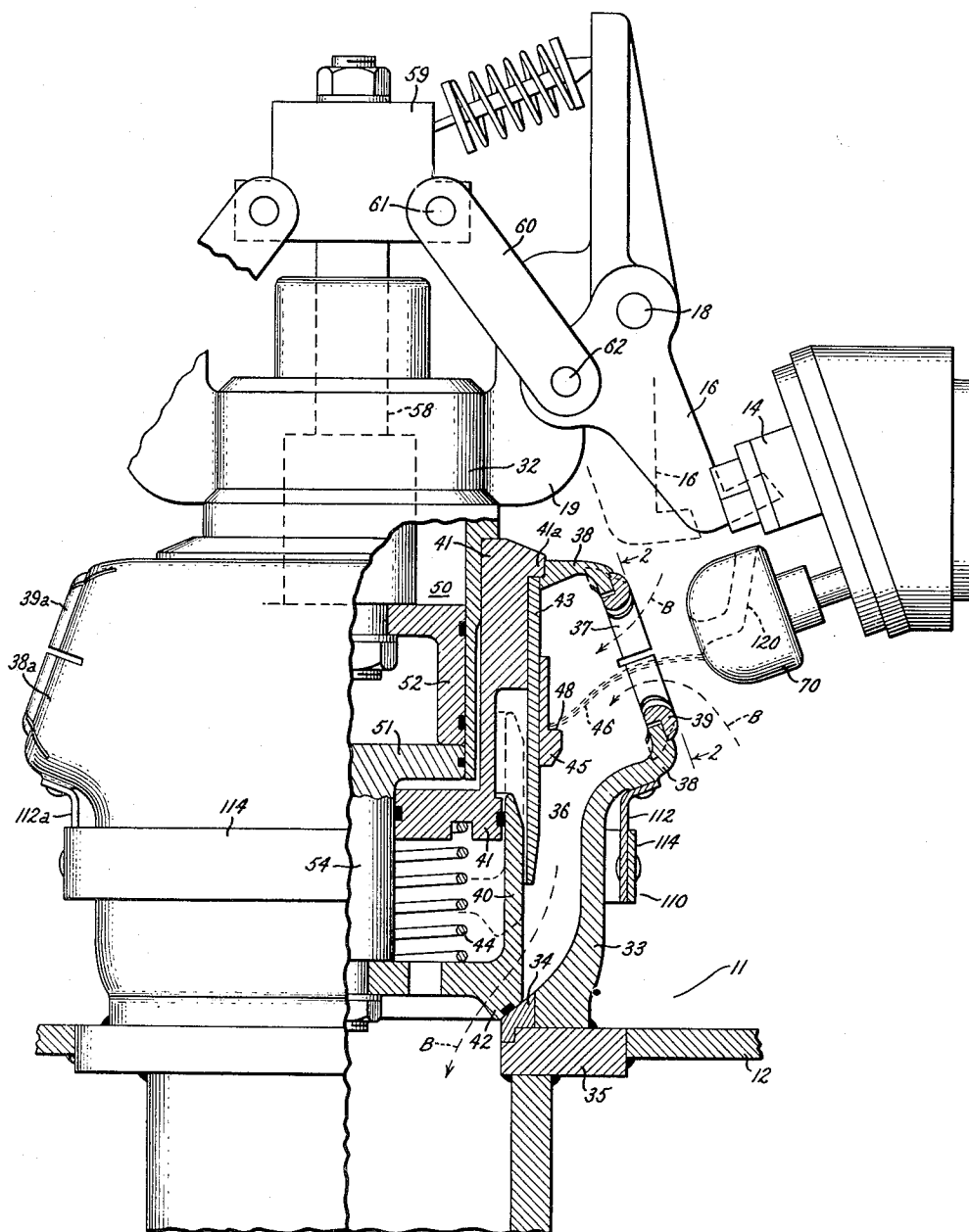
3,178,546

ORIFICE STRUCTURE FOR CIRCUIT INTERRUPTER OF FLUID BLAST TYPE

Filed Dec. 4, 1961

2 Sheets-Sheet 1

FIG. 1.



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2 Sheets-Sheet 2

FIG. 2.

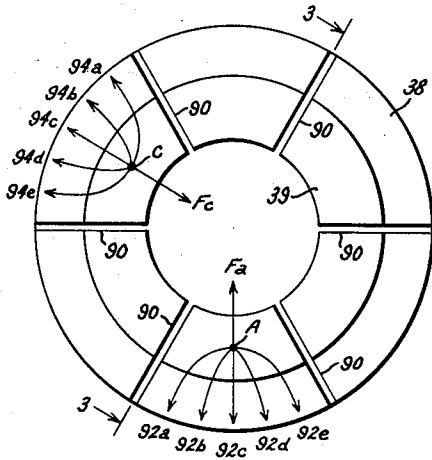


FIG. 3.

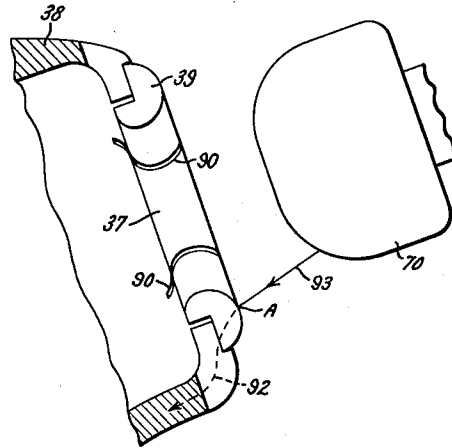


FIG. 4.

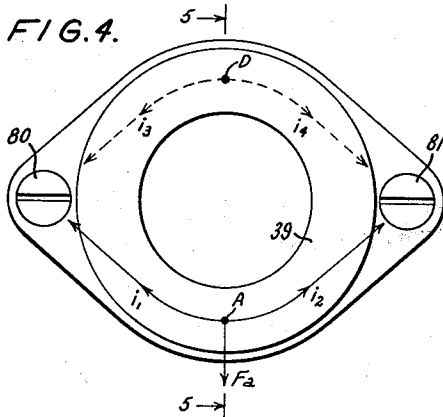


FIG. 7.

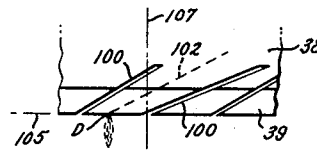


FIG. 6.

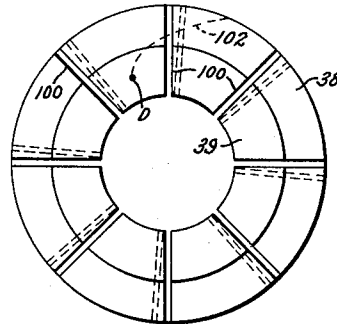
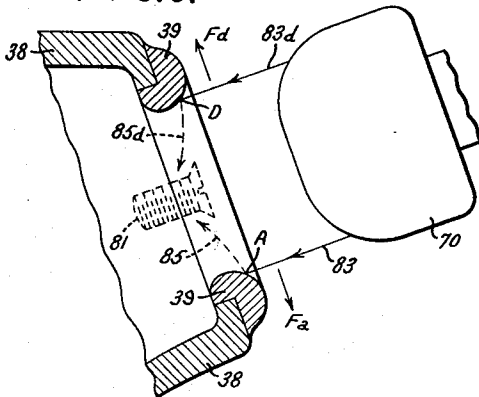


FIG. 5.



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ORIFICE STRUCTURE FOR CIRCUIT INTERRUPTER OF FLUID BLAST TYPE

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Filed Dec. 4, 1961, Ser. No. 156,672
12 Claims. (Cl. 200-148)

This invention relates to an electric circuit interrupter of the type that relies upon a fluid blast for deionizing the usual arc that is drawn during the circuit-interrupting operation. More particularly, the invention relates to a fluid-blast circuit interrupter of the type in which the arc is positioned to extend through an orifice through which the fluid blast flows at high speed during the arc-deionizing process.

In certain circuit interrupters of this type, the arc is initially drawn externally of the orifice, and thereafter the fluid blast transfers the downstream terminal of the arc to the metallic walls of the orifice structure and then through the orifice opening to a downstream electrode. During this transfer of the downstream terminal, the upstream terminal of the arc remains on the upstream side of the orifice so that when the transfer is completed, the arc extends axially through the orifice opening, it is when the arc is in this latter position that it can be most effectively cooled and deionized. For this reason, I refer to this latter position as the arc's most vulnerable position.

If the downstream terminal of the arc is blocked or unduly impeded from transferring to the downstream electrode, then the arc will be blocked or delayed from reaching its most vulnerable position. This can unduly prolong the interrupting operation and can also significantly reduce the amount of current that the interrupter can successfully interrupt.

I have found that in certain prior circuit breakers of this general type there are magnetic forces present when the downstream arc terminal reaches the orifice member that tend to oppose motion of the downstream terminal through the orifice opening. For the lower values of fault current, these magnetic forces, which vary in magnitude as a direct function of the current, are insufficient to withstand the oppositely-acting force of the fluid blast that tends to drive the downstream terminal through the orifice opening. But for the higher values of fault current, these magnetic forces can reach such a high level that they actually prevent the downstream terminal from passing through the orifice opening.

An object of my invention is to construct the orifice structure in such a manner that when the downstream arc terminal reaches the orifice structure, the magnetic forces on the arc do not oppose entry of the arc terminal through the orifice opening but actually aid the arc terminal in passing through the orifice opening.

Another object is to construct the orifice structure in such a manner that these magnetic forces act in a radially-inward direction so as to force the downstream arc terminal through the orifice opening.

Still another object is to construct the orifice structure in the manner described in the immediately preceding paragraph and also in such a manner that the arc terminal is spun circumferentially about the orifice structure. This latter action precludes excessive erosion of the orifice structure in any localized region of its periphery.

In carrying out my invention in one form, I provide a gas-blast type of electric circuit breaker that comprises a hollow metallic orifice structure defining an orifice opening through which pressurized gas is caused to flow during circuit interruption. Means is provided for establishing an arc adjacent the orifice structure and externally thereof. When the arc is so established, a blast of pressurized gas

passes through the orifice opening and is effective to transfer one terminal of the arc to the orifice structure. When the arc terminal is transferred to the orifice structure, arc-motivating means becomes effective to cause the magnetic force on the arc to act in a direction to drive the arc radially inward of the orifice structure. The arc-motivating means comprises slots in the orifice structure that cause the net current flowing from said one terminal of the arc through the orifice structure to follow a path that extends from the terminal radially-outward with respect to the orifice opening in the region of the arc terminal.

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

FIG. 1 is a sectional view of a gas blast circuit interrupter embodying one form of my invention.

FIG. 2 is an enlarged sectional taken along the line 2-2 of FIG. 1.

FIG. 3 is a sectional view taken along the line 3-3 of FIG. 2.

FIG. 4 is a view taken along a line corresponding to the line 2-2 of FIG. 1 but showing a prior construction that is not being claimed in the present application.

FIG. 5 is a sectional view along the line 5-5 of FIG. 4.

FIG. 6 is a view similar to that of FIG. 2 of a modified form of my invention.

FIG. 7 is a plan view of a portion of the structure shown in FIG. 6.

Referring now to FIG. 1, the circuit interrupter shown therein is of the sustained-pressure, gas-blast type described and claimed in my U.S. Patent 2,783,338, assigned to the assignee of the present invention. Only those parts of the interrupter that are considered necessary to provide an understanding of the present invention have been shown in FIG. 1. In this respect, only the right hand portion of the interrupter has been shown in section inasmuch as the interrupter is generally symmetrical with respect to a vertical plane and the left hand portion is substantially identical to the right hand portion. As described in detail in my above-mentioned patent, the interrupter comprises a casing 12 which is normally filled with pressurized gas to define an interrupting chamber 11. Located within the interrupting chamber 11 are a pair of relatively movable contacts 14 and 16 which can be separated to draw an arc within the pressurized gas within the chamber 11. The contact 14 is relatively stationary, whereas the other contact 16 is mounted for pivotal motion about a fixed, current-carrying pivot 18. When the movable contact 16 is driven clockwise about the pivot 18 from its solid-line closed position of FIG. 1, an arc is established in the region where the contacts part. The movable contact 15 is shown by dotted lines in FIG. 1 in a partially-open position through which it passes during a circuit-interrupting operation after having established an arc.

The movable contact 16 is supported by means of its current-carrying pivot 18 on a conductive bracket 19 that is preferably formed integral with a stationary cylinder 32. The cylinder 32 at its lower end is suitably supported from a generally cylindrical casting 33. The casting 33 at its lower end is suitably secured to a flange 35 rigidly carried by the stationary metallic casing 12.

For producing a gas blast to aid in extinguishing the arc, the cylindrical casting 33 contains a normally-closed exhaust passage 36 leading from the interrupting chamber 11 to the surrounding atmosphere. The casting 33 at its upper end is provided with a tubular nozzle-type electrode 38 having an orifice portion 39 at its outer end defining an inlet 37 to the exhaust passage 36. This inlet 37 is referred to hereinafter as the orifice opening.

The flow of arc-extinguishing gas through the tubular nozzle 38 and the exhaust passage 36 is controlled by means of a cylindrically-shaped reciprocable blast valve member 40 located at the outer, or lower, end of the exhaust passage 36. This blast valve member 40 normally occupies a solid-line, closed position wherein an annular flange 42 formed at its lower end sealingly abuts against a stationary valve seat 34 carried by the exhaust casting 33.

During a circuit interrupting operation, the movable blast valve member 40 is driven upwardly from its solid-line, closed position of FIG. 1 through a partially open intermediate position shown in dotted lines in FIG. 1. Opening of the valve member 40 allows pressurized gas in the chamber 11 to flow at high speed through the orifice opening 37 and nozzle 38 and out the exhaust passageway 36 past the valve member 40 to atmosphere, as indicated by the dotted line arrows B of FIG. 1. The manner in which the gas blast acts to extinguish the arc will soon be described in greater detail.

At its upper end, the cylindrical valve member 40 surrounds a projecting tubular support 41 upon which the valve member 40 is smoothly slidable. The tubular support 41 is fixed to the casting 33, preferably, by means of bolts (not shown) clamping the flange 41a to the top of casting 33. A compression spring 44 positioned between the movable valve member 40 and the lower end of support 41 tends to hold the valve member 40 in its closed position against the valve seat 34.

To protect the support 41 and the upper end of the valve member 40 from the harmful effects of arcing, a protective metallic tube 43 is positioned about these parts and is suitably secured to the support 41. Secured to the outer surface of this tube is a downstream probe or electrode 45, preferably of a refractory metal, which projects radially from the tube 43 and transversely into the path of the gas blast flowing through the passageway 36. As will soon appear more clearly, the downstream terminal of the arc is transferred to this electrode 45 during an interrupting operation and, after such transfer, occupies a position generally corresponding to that shown at 46. The downstream electrode is preferably constructed as shown and claimed in Patent No. 2,897,324, Schneider, assigned to the assignee of the present invention, so that it has a non-streamlined upstream surface 48 that coacts with the gas blast to form a stagnation region upstream from the surface 48. The terminal of an arc such as 46 reaching the electrode 45 is captured within the stagnation region and thus prevented from being driven further downstream by the gas blast.

For controlling the operation of the movable gas valve 40 and movable contact 16, a combined operating mechanism 50 is provided. This mechanism 50 is preferably constructed in the manner disclosed and claimed in my aforementioned Patent 2,783,338, and its details form no part of the present invention. Generally speaking, this mechanism 50 comprises a valve-controlling piston 51 and a contact-controlling piston 52 mounted within the cylinder 32. The valve-controlling piston 51 is coupled to the movable valve member 40 through a piston rod 54 suitably clamped to the valve member 40. The contact-controlling piston 52, on the other hand, is connected to the movable contact 16 through a piston rod 58 and a cross head 59 secured to the piston rod. A line 60 pivotally joined to the cross head 59 at 61 and to the movable contact 16 at 62 interconnects the cross head 59 and the movable contact 16. When the valve-controlling piston 51 is driven upwardly, it acts to open the valve member 40, and, simultaneously, to drive the contact-controlling piston 52 upwardly to produce opening movement of the movable contact member 16.

Opening movement of the contact member 16 first establishes an arc between the ends of the contacts 14 and 16. Shortly thereafter, however, the blast of gas which has been flowing through the orifice opening 37, as indi-

cated by the dotted-line arrows B, forces the upstream terminal of the arc on to an upstream arcing electrode 70, which is electrically connected to the stationary contact 14. As opening motion of the movable contact 16 continues, the gas blast forces the downstream terminal of the arc to transfer from the movable contact 16 to orifice structure 39, which is electrically connected to the movable contact 16. The gas blast then impels the downstream terminal of the arc through the orifice opening 37 and nozzle 38 on to the upper end of the protective metallic tube 43. From there, the gas blast drives the downstream arc terminal downwardly and into the previously-described stagnation region adjacent the downstream surface 48 of the electrode 45. The arc then occupies the position generally shown in 46. When the arc is in this position, the arc column extends through the orifice opening 37 and is subjected in the orifice region to an intense high velocity blast. This blast is effective to cool and deionize the arc and to prevent reignition thereof at an early current zero. The downstream electrode 45 and the upstream electrode 70 are so located that the length of the arc and the position of the arc are at optimum values to facilitate high speed arc-extinction. In other words, this is the position of the arc in which it is most vulnerable to extinction.

To achieve high speed arc-extinction, it is important that entry of the downstream arc terminal through the orifice opening 37 not be blocked or unduly impeded in any way. Otherwise, entry of the arc into its most vulnerable position of FIG. 1 will be prevented or delayed, and this will seriously detract from the desired high speed of the arc-extinguishing process. A serious, and heretofore largely unrecognized, deterrent in many prior constructions to the high speed entry of the arc terminal through the orifice opening has been the presence of magnetic forces tending to oppose such entry. So long as the currents being interrupted are relatively low, these magnetic forces, which are directly dependent upon the square of the current magnitude are also low and can be readily overcome by the action of the gas blast. But at the higher levels of fault current, these magnetic forces can become so high that they seriously impede or even completely block entry of the arc terminal through the orifice opening.

To illustrate more specifically the manner in which prior constructions have developed magnetic forces tending to oppose entry of the arc terminal through the orifice opening, reference may be had to FIGS. 4 and 5. Here the orifice portion 39 is constructed as a continuous essentially imperforate ring attached to the remainder of the nozzle 38 by screws 80 and 81 passing through suitable laterally-projecting ears formed as an integral part of the orifice ring 39. Beneath these screws 80 and 81 are the two principal contact areas between the orifice member 39 and the remainder of the nozzle 38, so that most of the current flowing into the supporting walls of the nozzle flows through these contact areas. When the downstream terminal of the arc attaches to the orifice ring 39 at any point thereon, such as A, the current from the arc, in order to enter the supporting walls of the nozzle 38, must now flow circumferentially around the orifice ring 39 to the screw locations 80 and 81 before entering the supporting walls of the nozzle. In the particular case shown, i.e., where the arc terminal is located along the vertical center line at A, the current will split equally to the left and right, as indicated by the currents i_1 and i_2 , so that the net horizontal current component is zero. There will, however, be a vertical component directed toward the center of the orifice member 39 equal to the vector sum of the vertical components of i_1 and i_2 . Referring to FIG. 5, it will be seen that the path 85 of this vertical component of current and the path 83 of the current flowing through the arc form a current loop that bows in a direction away from the center of the

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orifice member 39. When current flows through such a loop circuit, the magnetic forces present tend to lengthen the loop, and this tendency results in the presence of a force F_a in FIGS. 4 and 5 acting in a direction to drive the arc away from the center of the orifice structure 39. For high fault currents, this force F_a can become so high as to block entry of the arc terminal through the orifice opening despite the force of the gas blast tending to impel the arc terminal through the orifice opening.

To illustrate the force on the arc when the downstream terminal is at some other position on the orifice structure, assume that the terminal is located on the upper portion of the orifice at D. The current flowing from D will split into two parts i_3 and i_4 , so that there will be a net vertical component toward the center of the orifice member 39 equal to the vector sum of the vertical components of i_3 and i_4 . Referring to FIG. 5, the path 85d of this vertical component and the path 83d of the current flowing through the arc form a loop that bows in a direction away from the center of the orifice member 39. This results in a force F_d acting in a direction to drive the arc away from the center of the orifice structure, i.e., a radially-outward direction.

In FIGS. 4 and 5, the force on the arc will be in a radially-outward direction for any location of the arc terminal on the orifice ring 39 except directly adjacent the screws 80 and 81, because in all of these locations except the latter two, there is vertical component of current flowing from the arc terminal in a radially-inward direction. At first thought, it might appear that all the is necessary to eliminate this force would be to provide a good electrical connection between the orifice ring 39 and the remainder of the nozzle 38 about the entire periphery of the orifice member. But this would not adequately solve the problem, because a substantial part of the current flowing from the arc terminal into the nozzle walls would still flow around the periphery of the orifice ring to other portions of the nozzle. The result is a net component of current flowing over a path extending radially-inward and thus a force acting to drive the arc radially-outward.

To eliminate this radially-outward force on the arc and to provide instead a force that acts to drive the arc in a radially-inward direction, I have provided the orifice structure 39 with slots 90 that extend from the exposed face of the orifice structure back into the supporting walls of the nozzle 38. The individual sections of the orifice structure between adjacent slots 90 are brazed or otherwise suitably joined to the remainder of the nozzle structure so as to provide a good electrical and mechanical connection across this interface. These slots 90, which are best shown in FIGS. 2 and 3, force current flowing from an arc terminal into the supporting wall of the nozzle 38 to follow a resultant path which extends radially-outward from the arc terminal. For example, in FIG. 3 it will be seen that the current flowing from the arc terminal A through the orifice member 39 and the remainder of the nozzle 38 follows a resultant path 92 that extends radially-outward from the arc terminal. This path 92 and the path 93 of current through the arc form a loop circuit, but this loop bows radially-inwardly, as can be seen in FIG. 3. The magnetic forces that tend to lengthen the loop thus act in a direction to drive the arc radially inward instead of radially outward as in FIGS. 4 and 5. Accordingly, the magnetic forces instead of opposing entry of the arc terminal through the orifice opening 37 actually aid such entry. As explained hereinabove, this materially shortens the interrupting process and, in some cases, substantially increases the amount of current the interrupter can successfully interrupt.

To facilitate an understanding of the manner in which the slots 90 force current flowing from an arc terminal through the wall of the orifice and nozzle structure 38, 39 to flow radially outward, reference may be had to FIG. 2, which is an end view of the orifice and nozzle structure

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38, 39. If it be assumed that the arc terminal is momentarily located at A, then it will be apparent that the current flowing from A through the orifice structure 39 and the remainder of the nozzle 38 will follow paths such as 92a, 92b, 92c, 92d, and 92e, which may be considered to be components of the path 92 of FIG. 3. These paths 92a-92e have a net radial component extending radially-outward, and thus the magnetic force on the arc is radially-inward, as indicated by the force F_a shown in FIG. 2.

A corresponding force acting to drive the arc in a radially-inward direction is present irrespective of the particular circumferential position of the arc terminal on the orifice member 39. For example, if the arc terminal should be located at C in FIG. 2, the current flowing from the arc terminal at C through the walls of the nozzle structure 38, 39 follows paths 94a-94e extending radially-outward, and hence the magnetic force on the arc is radially-inward, as is indicated by the arrow F_c of FIG. 2.

It should be apparent that it is not only the slots 90 that are responsible for the flow of current from the arc terminal in a radially-outward direction but also the fact that the walls of the nozzle 38, 39 adjacent the orifice opening 37 extend generally radially with respect to the orifice opening 37 about substantially the entire periphery of the orifice opening. These two features coact to force current flowing from an arc terminal at substantially any circumferential point on the orifice structure 39 to flow radially-outward with respect to the orifice opening. When the polarity of the current reverses, the loop circuit still bows in the same direction, and thus the magnetic force on the arc is still radially-inward.

In addition to driving the arc terminal through the orifice opening 37, it is sometimes desirable to move the arc terminal circumferentially about the orifice structure during the brief interval that its downstream terminal is attached thereto. This circumferential motion helps to avoid excessive arc erosion at any localized circumferential portion of the orifice structure, particularly at the slots, where the arc terminal sometimes tends to hang while on the orifice structure. For providing a circumferentially-acting force on the arc to effect such circumferential motion, I provide the orifice with slots 100 that have the skewed configuration shown in FIGS. 6 and 7. Here the slots, instead of extending perpendicular to the axially-outermost face of the orifice ring 39, extend at an acute angle to this face. More specifically, referring to FIG. 7, the slots 100 may be thought of as extending at an acute angle relative to a reference plane 105 that is normal to the centrally-located longitudinal axis 107 of the nozzle 38. This configuration of the slots forces current flowing from a terminal of the arc, for example at B, to follow a path 102 that has a net component extending circumferentially as well as radially-outward. There is thus a tangentially-acting loop circuit that has a magnetic effect tending to impel the arc circumferentially around the orifice ring 39. This is in addition to the previously described magnetic force tending to drive the arc through the orifice opening. Thus, for the brief period when the arc terminal is located on the orifice member 39, it is moved circumferentially as well as radially-inward.

To accentuate the forces tending to drive the arc terminal radially-inward when the arc terminal is located on the lower portion of the orifice structure 39, as at A in FIGS. 2 and 3, I provide the conductive structure 110 of FIG. 1. This conductive structure 110, which is of low resistivity metal in comparison to that of casting 33, provides a low impedance path through which the major portion of the current from the arc terminal at A flows radially-outward after leaving the nozzle structure 38, 39. To this end, the conductive structure 110 has an arm 112 extending radially outward with respect to the nozzle 38 and electrically-joined to the nozzle adjacent the base of the fingers between the slots 90. A similar arm 112a is provided at the left-hand nozzle structure 38a, 39a, and

the two arms are electrically connected together by a conductive ring 114 surrounding the casting 33. A large portion of the current flowing between the two nozzles flows through the arms 112 and 112a via this ring 114.

The reason for locating the conductive bridging structure 110 at the lower side of the nozzles 38, 38a can be best understood by first assuming that this bridging structure was omitted. Assume next that the part 41 of FIG. 1 is of a metal having a low electrical resistivity, such as aluminum, whereas the casting 33 is of steel, a metal with a relatively high electrical resistivity. Also, recall that the part 41 is bolted to the casting 33 at the top of the casting 33 so that the principal contact regions between parts 41 and 33 are at the top of the casting 33. Because of the low electrical resistance of the aluminum part 41, there is a tendency in such a structure for an unduly large portion of the current to flow between the nozzles 38 and 38a via the top portion of the intermediate structure 33, 41. If an arc terminal is located at A, then the portion of the current that flows via the top portion of the intermediate structure 33, 41 must flow generally upward after leaving the slotted portion of the nozzle 38, 39. Current following such a generally upward path has a tendency to partially neutralize the magnetic effect on the arc resulting from current following the generally downward path 92 of FIG. 3 since these current paths are to some extent in opposite directions. I have materially reduced this neutralizing effect, however, by providing a low resistance bypass in the form of highly-conductive bridging structure 110 through which most of the current from the arc terminal at A is forced to flow. By following this path below the nozzles 38, 38a instead of a path at the top of the nozzles, the current flowing between the nozzles has a materially reduced tendency to neutralize the magnetic effect on the arc of the current flowing through the path 92. Thus, with the conductive bridging structure 110 present and the arc terminal at A, there is still a strong magnetic action tending to force the arc radially inward, as described hereinabove.

It will be noted that the location of the connection between the conductive bridging structure 110 and the nozzles 38 and 38a is confined to one diametrical side of each of the nozzles. Thus, when current flows from an arc terminal at D, i.e., adjacent the top of the orifice structure 39, a substantial portion of this current still flows via the top portion of the intermediate structure 33, 41. There is sufficient impedance in the conductive path extending from D to the conductive bridging structure 110 to prevent a major portion of the current flowing from D from following the conductive bridging structure 110. Thus, there is still an effective radially-outward path for current flowing from point D through the nozzle structure 38 despite the presence of the conductive bridging structure 110.

With respect to the upstream arcing electrode 70 illustrated in FIG. 1, it will be noted that a centrally disposed passageway 120 is provided therein. One of the purposes of this passageway is to encourage motion of the upstream arc terminal on this electrode by denying it a possibly-stable footing at the center of the electrode 70. This aids in reducing arc-erosion of the electrode 70. Forcing the arc away from the center of the upstream electrode also helps locate the arc in such a position that the magnetic effect of the loop circuit of FIGS. 2 and 3 is to drive the arc radially-inward relative to orifice structure 39. In other words, the path 92 of FIG. 3 becomes more nearly perpendicular to the arc path 93.

While I have shown and described particular embodiments of my 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. I, therefore, intend in the appended claims to cover all such changes and 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. An electric circuit breaker of the fluid blast type comprising:

- (a) a tubular nozzle comprising a hollow orifice portion at the axially outer end of said nozzle, said hollow orifice portion defining internally thereof an orifice opening through which a blast of pressurized fluid is adapted to enter said tubular nozzle during circuit interruption,
- (b) said nozzle having a conductive wall portion surrounding said orifice opening that extends generally radially outward from said orifice opening about substantially the entire periphery of the orifice opening,
- (c) means including a contact separate from said orifice portion and upstream therefrom for establishing an arc adjacent said orifice portion and upstream therefrom,
- (d) means for producing a blast of pressurized fluid through said orifice opening which is effective to transfer one terminal of said arc from said contact to said orifice portion while the other terminal of said arc remains upstream therefrom,
- (e) said arc being subject to a magnetic force acting thereon, the direction of which is dependent upon the shape of the current path extending through and adjacent said arc,
- (f) arc-motivating means effective upon transfer of said one arc terminal to said orifice portion for causing the magnetic force on said arc when said arc is at any angular location on said orifice portion to act in a direction to drive said arc radially-inward of said orifice portion, said arc-motivating means comprising slots in said wall portion surrounding said orifice opening that cause the net current flowing from said one arc terminal through said surrounding wall portion to follow a path that extends from said one arc terminal radially-outward with respect to said orifice opening,
- (g) and a downstream electrode to which said one arc terminal is transferred upon passing through said orifice opening, whereby the column of the arc then extends through the orifice opening.

2. The circuit breaker of claim 1 in which said hollow nozzle has a centrally located longitudinal axis extending through said hollow orifice portion, and in which said slots extend at an acute angle relative to a reference plane that is normal to said longitudinal axis.

3. The circuit breaker of claim 1 in which said hollow nozzle has a centrally located longitudinal axis extending through said hollow orifice portion, and in which said slots extend generally perpendicular to a reference plane that is normal to said longitudinal axis.

4. The circuit breaker of claim 1 in which said slots are of a skewed configuration that forces the net current flowing from an arc terminal located at substantially any angular location on the periphery of the orifice portion to follow a path that extends circumferentially with respect to the orifice portion adjacent the arc terminal.

5. The circuit breaker of claim 1 in combination with conductive structure of a material having a low resistivity in comparison to that of said nozzle wall portion forming a low impedance path at one diametrical side of said orifice portion for carrying a major portion of the current flowing from said orifice portion away from said arc when an arc terminal is located at said one side of said orifice portion, and means for preventing a major portion of the current flowing from an arc terminal on a diametrically opposed side of said orifice portion from following a path through said low resistivity conductive structure at said one diametrical side.

6. The circuit breaker of claim 1 in combination with first conductive structure of a material having a resistivity low in comparison to that of said nozzle wall portion forming a low impedance path at one diametrical side of said orifice portion for carrying a major portion of the current flowing from said orifice portion when an arc

terminal is located at said one side of said orifice portion, and second conductive structure at a generally diametrically opposed side of said orifice portion forming a low impedance path for current flowing from an arc terminal at said diametrically-opposed side of said orifice portion, and means for preventing a major portion of the current flowing from an arc terminal at said diametrically opposed side of the orifice portion from following a path through said first conductive structure.

7. The circuit breaker of claim 1 in combination with conductive structure of a material having a resistivity low in comparison to that of said nozzle wall portion forming a low impedance path at one diametrical side of said orifice portion for carrying a major portion of the current flowing from said orifice portion when an arc terminal is located at said one side of said orifice portion, said low impedance path being of such a configuration that it directs current in a radially-outward direction after leaving said one side of said orifice portion, and means for preventing a major portion of the current flowing from an arc terminal at a diametrically opposed side of said orifice portion from following a path through said low resistivity conductive structure at said one diametrical side of said orifice portion.

8. An electric circuit breaker of the fluid-blast type comprising:

- (a) hollow metallic orifice structure defining an orifice opening through which pressurized fluid is adapted to flow during circuit interruption,
- (b) means including a contact separate from said orifice structure and located upstream therefrom for establishing an arc adjacent said orifice structure and upstream therefrom,
- (c) means for producing a blast of pressurized fluid through said orifice opening which is effective to transfer one terminal of said arc from said contact to said orifice structure, while the other terminal of said arc remains upstream from said orifice,
- (d) said arc being subject to a magnetic force acting thereon, the direction of which is dependent upon the shape of the current path extending through and adjacent said arc,
- (e) and arc-motivating means effective upon transfer of said one arc terminal to said orifice structure for causing the magnetic force on said arc to act in a direction to drive said arc radially-inward of said orifice structure, said arc-motivating means comprising slots in said orifice structure that cause the net current flowing from said one arc terminal through said orifice structure to follow a path that extends from said one arc terminal radially-outward with respect to said orifice opening in the region of said one arc terminal,
- (f) and a downstream electrode to which said one arc terminal is adapted to be transferred by said fluid blast upon passing through said orifice opening, whereby the column of the arc then extends through said orifice opening.

9. The circuit breaker of claim 8 in which said arc-motivating means comprises a sufficient number of slots in said orifice structure to cause the net current flowing from an arc terminal located at substantially any circumferential point on said orifice structure to follow a path that extends from said arc terminal radially-outward with respect to said orifice opening in the region of said arc terminal.

10. An electric circuit breaker of the fluid blast type comprising:

- (a) a pair of tubular nozzles each comprising a hollow orifice portion at the axially outer end thereof, said hollow orifice portion defining internally thereof an orifice opening through which a blast of pressurized fluid is adapted to enter said tubular nozzle during circuit interruption,
- (b) each of said nozzles having a wall portion sur-

rounding said orifice opening that extends generally radially outward from said orifice opening about substantially the entire periphery of the orifice opening, (c) means for establishing series-related arcs adjacent the respective orifice portions and upstream therefrom,

(d) means for producing a blast of pressurized fluid through each of said orifice openings which is effective to transfer one terminal of the associated arc to said orifice portion while the other terminal of said associated arc remains upstream therefrom,

(e) said arc being subject to a magnetic force acting thereon, the direction of which is dependent upon the shape of the current path extending through and adjacent said arc,

(f) arc-motivating means associated with each of said nozzles and effective upon transfer of said one arc terminal to said orifice portion for causing the magnetic force on said arc to act in a direction to drive said arc radially-inward of said orifice portion, said arc-motivating means comprising slots in said wall portion of each nozzle surrounding said orifice opening that cause the net current flowing from said one arc terminal through said surrounding wall portion to follow a path that extends from said one arc terminal radially-outward with respect to said orifice opening,

(g) and a downstream electrode associated with each nozzle to which said one arc terminal of the associated arc is transferred upon passing through said orifice opening, whereby the column of the associated arc then extends through the orifice opening,

(h) supporting structure of a relatively high resistivity metal carrying said nozzles and forming a conductive path between the arcs associated with the respective nozzles,

(i) and conductive bridging structure of a relatively low resistivity metal electrically connected to each of said nozzles for forming a low impedance conductive path between said nozzles, said conductive bridging structure being connected to said nozzles at one diametrical side of each of said orifice portions so as to carry a major portion of the current flowing from said orifice portion when an arc terminal is located at said one side of said orifice portion, the location of the connection between said conductive bridging structure and each nozzle being confined to said one side of said orifice portion.

11. The circuit breaker of claim 10 in combination with second conductive structure at a generally-diametrically opposite side of said orifice portion forming a low impedance path for current flowing from an arc terminal located at said opposite side of said orifice portion, said second conductive structure being of a metal having a lower resistivity than that of said nozzle-supporting structure.

12. The circuit breaker of claim 1 in combination with an upstream electrode on which the upstream terminal of said arc is located during interruption, said upstream electrode being generally aligned with said orifice portion and having means associated therewith for urging the upstream terminal of said arc into locations where said radially-outward current path at said orifice portion is more nearly perpendicular to said arc.

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