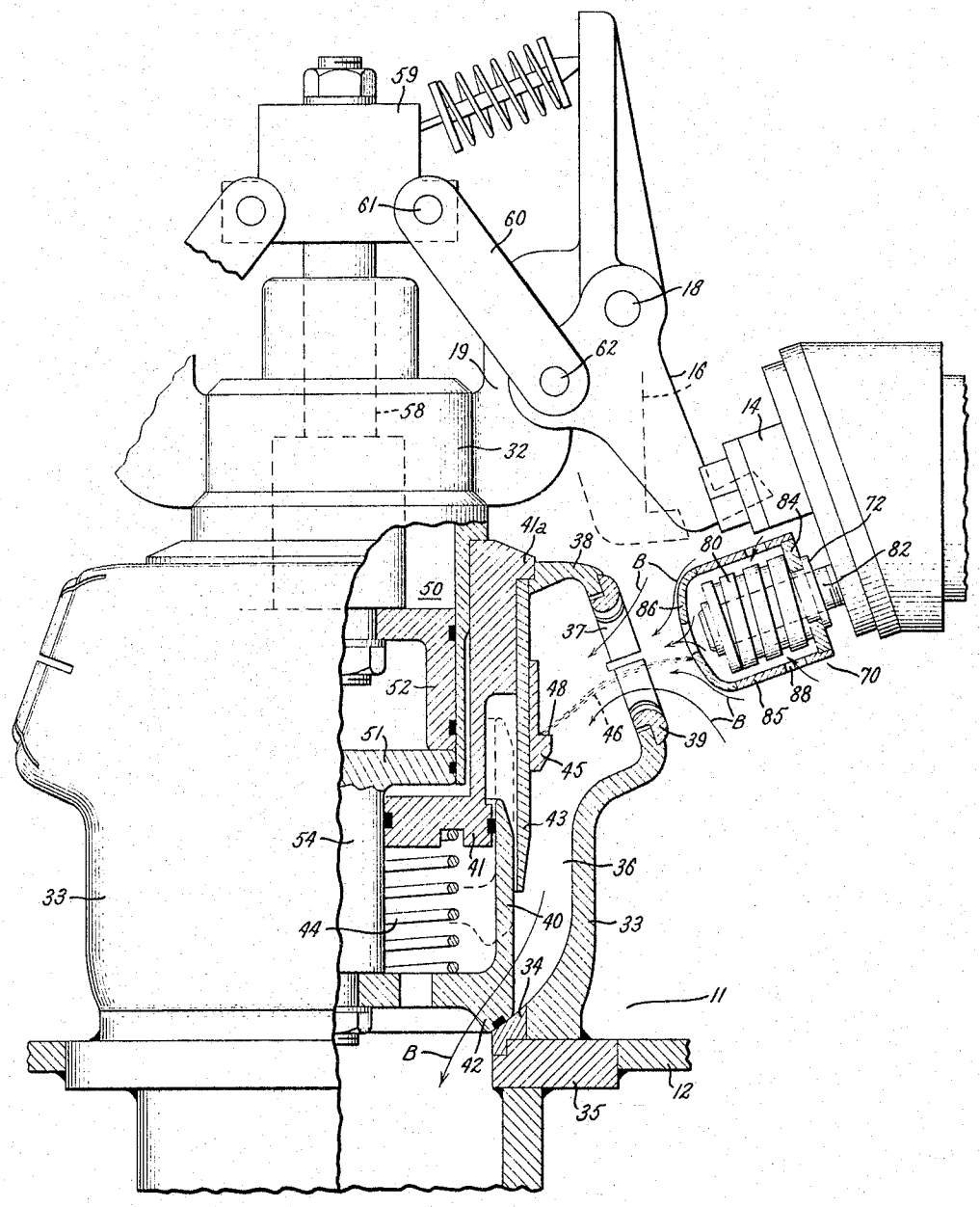
Sept. 20, 1966 J. W. BEATTY 3,274,365

GAS BLAST CIRCUIT BREAKER OF THE AXIAL BLAST TYPE WITH MAGNETIC MEANS FOR ROTATING AN ARC TERMINAL

Filed Aug. 16, 1963 2 Sheets-Sheet 1

FIG. 1.



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Filed Aug. 16, 1963 2 Sheets-Sheet 2

FIG. 2.

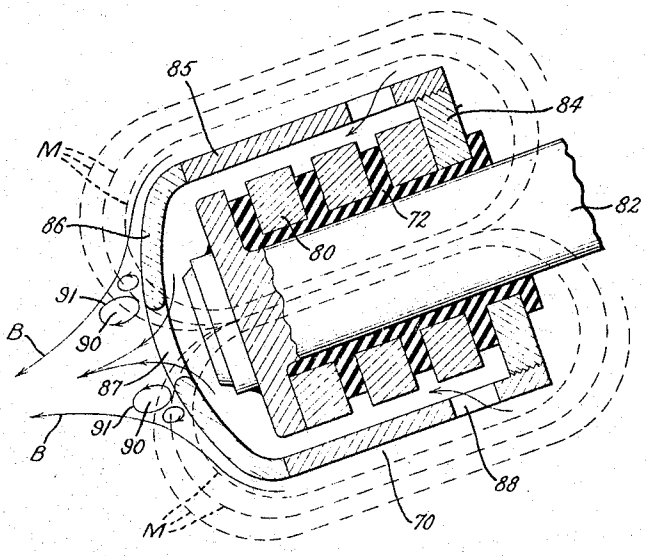


FIG. 3.

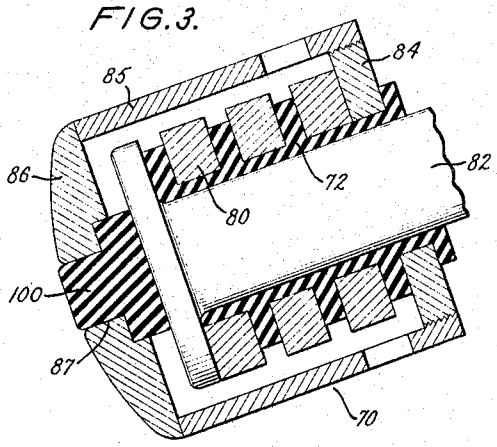


FIG. 4.

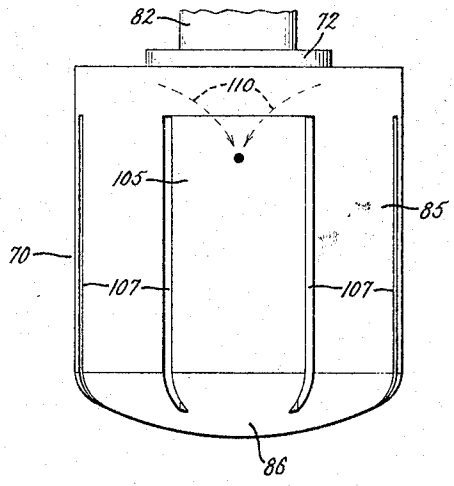
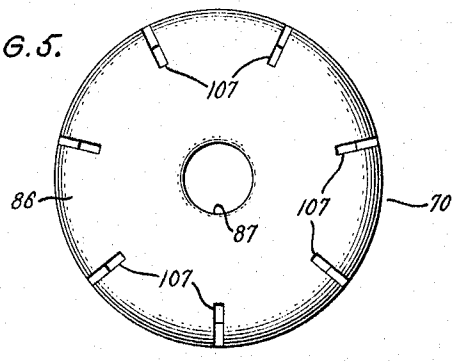


FIG. 5.



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United States Patent Office 3,274,365 Patented Sept. 20, 1966

3,274,365

GAS BLAST CIRCUIT BREAKER OF THE AXIAL BLAST TYPE WITH MAGNETIC MEANS FOR ROTATING AN ARC TERMINAL

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Filed Aug. 16, 1963, Ser. No. 302,613
8 Claims. (Cl. 200—148)

This invention relates to a gas blast circuit breaker of the axial blast type and, more particularly, to means for improving the interrupting ability of such a circuit breaker.

The usual gas blast circuit breaker comprises means for establishing an electric arc across a gap between two electrodes and means for directing a high velocity blast of gas into the arcing region. The purpose of the gas blast is to cool the arc and to scavenge the arcing region of arcing products so as to increase the rate at which dielectric strength is built up across the gap when the current zero point is reached. By increasing this rate of dielectric recovery, it is possible to improve the ability of the gap to withstand the usual recovery voltage transient which builds up as soon as current zero is reached, thus improving the interrupting ability of the circuit breaker.

In an axial blast type of circuit breaker, there is typically provided an orifice through which the arc between the electrodes extends and through which the gas blast flows axially of the arc about the periphery of the arc. The purpose of the orifice is to guide the blast with respect to the arc and to impart the desired high velocity to the blast. The electrode that is located upstream from the orifice is referred to hereinafter as the upstream electrode, and the electrode that is located downstream from the orifice is referred to hereinafter as the downstream electrode.

A typical axial blast circuit breaker is so designed that the gas blast forces the arc into a stable position where it is held captive until extinguished at a current zero. Any tendency of the arc to move out of this stable position is counteracted by relatively high aerodynamic forces on the arc resulting from the gas blast.

It has been proposed heretofore to improve the interrupting ability of a circuit breaker by magnetically moving the arc so as to promote cooling, but such magnetic arc moving schemes have largely been limited to circuit breakers in which the arc is not held captive by a high velocity blast of fluid, and therefore such schemes have not generally been used in the axial blast type of gas blast circuit breaker. Magnetic arc moving schemes have largely been ignored for this axial blast type of breaker primarily because it has geen generally thought that the magnetic forces developed by any practical magnetic arrangement would be so small in comparison to the large aerodynamic forces prevailing that such magnetic means would serve no useful purpose.

An object of my invention is to incorporate magnetic arc moving means into an axial gas blast circuit breaker in such a manner as to improve its rate of dielectric recovery when the current zero point is reached.

Another object is to incorporate arc rotating means into an axial blast circuit breaker in such a manner that the arc rotating means is capable of rotating the upstream terminal of the arc for all positions that this terminal may reach while held captive within the aerodynamically stagnant region adjacent the upstream electrode.

In the disclosed circuit breaker, the downstream terminal of the arc is held captive within a stagnation region upstream from the downstream electrode and is thus prevented from moving further downstream, where it could damage various sensitive parts of the circuit breaker. Another object is to produce the desired arc rotation without

dislodging the downstream terminal of the arc from its captive relationship with the downstream electrode.

In carrying out my invention in one form, I provide a gas blast circuit breaker of the axial blast type that comprises a downstream electrode and an upstream electrode between which an arc is established. An orifice is provided about the region in which the arc is located when present between the electrodes. Means is provided for causing a blast of pressurized gas to flow at high speed about the upstream electrode and through the orifice axially of the arc about the arc periphery toward the downstream electrode. This axial blast of gas envelopes the upstream electrode and establishes a stagnation zone, or wake, on the downstream side of the upstream electrode. The aerodynamic forces resulting from this gas blast force the upstream arc terminal into this stagnation zone. I rotate the upstream arc terminal within the stagnation zone by applying a radial magnetic field to the arc in the region of the upstream electrode. There is a central region disposed within the stagnation zone in which the radial magnetic field is weak and has little arc rotating capability, but I provide means for preventing entry of the upstream arc terminal into this central region so that the arc is continuously rotated while within the stagnation zone. This rotation of the arc within the stagnation zone has resulted in substantial improvements in the rate of dielectric recovery at current zero. Although the gas blast can ordinarily apply relatively high aerodynamic forces to the arc; in the stagnation zone these aerodynamic forces are relatively low and the magnetic means can therefore produce significant motion of the arc.

For a better understanding of my invention, reference may be had to the following description 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 view of the upstream electrode of the circuit interrupter of FIG. 1.

FIG. 3 is a sectional view of a modified form of upstream electrode.

FIG. 4 is a plan view of another modified form of upstream electrode.

FIG. 5 is an end view of the electrode of FIG. 4.

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 No. 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 **16** 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 41*a* 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 nonstreamlined 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 blast 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 link 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 vlave 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 indicated 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 upstream 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 that extends axially of the arc. This axial blast is effective to cool and deionize the arc and scavenge the arcing region of arcing products, thus preventing 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.

It is generally understood that the ability of a circuit breaker to prevent the arc from reigniting at a current zero depends upon the rate at which dielectric strength is recovered across the arcing region when arcing ceases at the current zero. The faster the dielectric recovery rate, the lower the chances for reignition and thus the better the chances for successful interruption at this point.

I have found that substantial improvements in this dielectric recovery rate can be made by rotating the upstream terminal of the arc about a central point on the downstream face of the upstream electrode 70. The magnetic force for rotating the arc is derived from a coil 80 electrically connected in series with the electrode 70 and located behind the downstream face of the electrode 70. This coil 80 encircles a conductive stud 82 which carries current to and from the upstream electrode. The left hand end of the coil 80 is electrically connected to the free end of the stud 82, and the right hand end of the coil is electrically connected to the electrode 70 at the rear end of the electrode 70. Suitable insulation 72 assures that current flowing through the electrode 70 will not bypass the coil 80 or any of its turns.

The electrode 70 is a cup-shaped member having an end cap 84 at its rear end to which the right hand end of the coil 80 is connected. The electrode 70 comprises a tubular wall portion 85 surrounding the coil 80 and a convex forward portion, or base portion, 86 of an arc-resistant refractory metal brazed to the tubular wall portion. The forward portion 86 has a centrally disposed opening 87 located therein, and the tubular wall 85 has openings 88 extending radially therethrough and communicating with the central opening 87. When the blast valve 40 of the circuit breaker is opened, as was described hereinabove, pressurized air not only flows into the orifice

39 via paths such as B but also via paths that extend radially inwardly through the openings 88 and then axially of the electrode 70 and out through the centrally disposed opening 87. This auxiliary blast of air through the opening 87 helps to prevent the arc terminal from entering the central opening 87 and finding a possible stable footing therein.

When the upstream arc terminal is transferred from the stationary contact 14 to the electrode 70, as was described hereinabove, it is forced by the main air blast enveloping the electrode 70 to move toward the forward end of the electrode. Current is then flowing through the coil 80 since the coil is connected in series with the arc. This current flowing through the coil 80 produces a magnetic field that extends generally radially with respect to the central opening 87 of the electrode in the region of the forward portion 86 of the electrode. The approximate configuration of this magnetic field is generally illustrated by the dotted lines of force M, which extend radially outward from the central opening 87 adjacent the electrode 70. This radial magnetic field reacts in a known manner with the local field surrounding the arc to produce a circumferentially acting magnetic force that rotates the upstream arc terminal about the central opening 87.

Magnetic arc rotating arrangements have heretofore largely been ignored for axial blast types of air blast circuit breakers, primarily because it has been generally thought that the magnetic forces developed by any practical magnetic arrangement would be so small in comparison to the large aerodynamic forces prevailing in such a breaker that such magnetic means would serve no useful purpose. This thinking, however, has overlooked the important fact that, even though the gas blast is traveling at high velocity past the electrode, the arc terminal can be located in a stagnation region in which the aerodynamic forces on the arc are relatively low. When the arc terminal is in such a zone of low aerodynamic force, a relatively small magnetic force on the arc can be a significant factor in moving the arc terminal. With the illustrated electrode 70, there is such a stagnation zone in the region immediately surrounding the central opening 87 of the electrode 70. This stagnation zone is designated 90 in FIG. 2. In this region the gas is moving at low velocity in large scale eddies such as illustrated by the closed loops 91. The air blast following the paths B will force the upstream arc terminal into this stagnation zone, where it will be held captive by the flow stream bounding the stagnation region. While the upstream arc terminal is captured in this manner in the stagnation zone 90, the radial magnetic field will rotate the upstream arc terminal about the central opening 87, as was described hereinabove.

It is important to note that the upstream arc terminal is excluded from the central region of the upstream electrode. The reason for this is that in the central region, the magnetic field resulting from current through the coil 80 has virtually no radial component. The direction of the field is almost entirely axial in the central region. Thus, the magnetic field would have little or no ability to rotate any arc that might have its terminal located in the central region. This being the case, the improvements obtainable from arc rotation would be largely nullified if the arc terminal were permitted to hang in this region. The fact that this central region contains an opening 87 and particularly an opening through which a blast of air is flowing prevents the arc from hanging in this region and thus preserves the effectiveness of the arc rotating arrangement.

FIG. 3 illustrates an alternative approach for excluding the upstream terminal of the arc from the region at the center of the upstream electrode. In this embodiment, a central opening 87 is provided in the central region of the electrode but instead of defining a flow passage, this central opening is filled with an insert 100 of arc resistant insulating material. A suitable insulating material for this insert is polytetrafluoroethylene, sold under the trade name of Teflon. Since there is no conductive metal in the central region to which the arc terminal can attach, it remains in the portion of the stagnation zone radially outside of the insulating insert 100. The upstream electrode of FIG. 3 is otherwise essentially the same as the electrode depicted in FIGS. 1 and 2, and corresponding reference numerals have been used to designate corresponding parts in the two embodiments.

It is to be noted that the upstream electrode 70 is of a hollow construction and that the current path through the electrode to or from any arc terminal on the electrode extends from the arc terminal to the rear end of the electrode. This current path together with the current path leading through an arc on the electrode forms a loop which bows in the direction of the stagnation region whenever the arc terminal is located on the electrode at a point outside the stagnation region. This desirably aids in moving the arc terminal into the stagnation region, where it can be rotated as described hereinabove. When the arc terminal is in the stagnation region, the loop ordinarily tends to force the terminal toward the center of the stagnation region where the arc rotating force is low. But the auxiliary blast in FIG. 2 and the insulating insert in FIG. 3 prevent the arc from reaching the center and thus assure the desired arc-rotation.

It is to be noted that my arc rotating means is confined to a location immediately adjacent the upstream terminal of the arc. Due to this location, the magnetic field M has a relatively strong radial component only in the region immediately adjacent the upstream electrode. At locations further downstream, this radial component of magnetic force is relatively weak. Thus the radial magnetic field acts primarily upon the portion of the arc immediately adjacent the upstream electrode. Accordingly, there is little tendency for the radial magnetic field to move the downstream arc terminal out of its captive location adjacent the downstream electrode. This is advantageous because if the downstream terminal were permitted to move out of its captive relationship it could be driven further downstream by the gas blast and possibly cause damage to vital parts of the circuit breaker.

FIG. 4 shows a modified form of upstream electrode 70 corresponding generally to that of FIG. 2 but differing therefrom in that slots 107 and an insert 105 of arc resistant refractory metal are provided in the electrode. The insert 105 is disposed in angular alignment with the forward end of stationary contact 14, and thus the insert is in a position to receive the upstream arc terminal when this terminal is transferred on to the upstream electrode. This insert 105 provides a path for the upstream arc terminal leading from a point where the arc terminal first attached to the electrode 70 to the forward portion 86 of the electrode. A preferred material for the insert 105 is a copper-tungsten mixture, sold under the trade name of Elkonite; the remainder of the tubular wall portion 85 of the upstream electrode is made of a highly conductive but less refractory material, such as copper.

The slots 107 have their long dimension extending longitudinally of the tubular wall portion 85 of the electrode, and a pair of adjacent slots border the insert 105. These slots also extend through the entire radial thickness of the wall portion 85. The purpose of the slots 107 is to force most of the current that flows through the electrode 70 to an arc terminal on the insert 105 to follow paths such as 110 which approach the arc solely through the insert 105 and from the back of the electrode. By forcing the current to follow such paths, a more definite loop bowing toward the forward face of the electrode is defined by the overall current path leading through the arc and the paths 110. This results in a greater magnetic force urging the arc toward the forward

face of the electrode. In addition, the slots **107** tend to block the flow of current to the arc terminal through paths that extend circumferentially of the electrode **70** and thus reduce the tendency of the arc to move circumferentially of the electrode until it reaches the forward face **86** of the electrode. By forcing the arc to move quickly to the forward face **86** of the electrode **70** by a path that is confined to the arc resistant insert **105**, the exposure of the less refractory portions of the electrode to the arc is substantially reduced and the possibilities for excessive arc-erosion are reduced.

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 my invention in its broader aspects, and 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 axial-blast, gas-blast type comprising:

(a) a pair of electrodes between which an arc is established during circuit interruption,

(b) an orifice having an opening through which said arc is adapted to extend when present between said electrodes,

(c) means for causing a stream of gas to pass through said orifice opening axially of the arc about the periphery of said arc,

(d) portions of said gas stream flowing closely adjacent to the outer periphery of the electrode located upstream from said orifice but separating from the surface of said electrode in a region facing the orifice opening, whereby to define a stagnation zone in said latter region,

(e) said arc having an upstream terminal that is held captive in said stagnation zone during a circuit interrupting operation,

(f) magnetic means for rotating said upstream terminal about a point on said upstream electrode while said upstream arc terminal is held captive in said stagnation zone,

(f') said upstream electrode comprising a generally cup-shaped member surrounding said magnetic means with the base of said cup-shaped member facing downstream with said stagnation zone positioned on said base, means for forcing current flowing through said cup-shaped member to an arc terminal in said stagnation zone to flow from the outer periphery of said cup-shaped member radially inwardly, thereby developing a radially-inwardly acting magnetic force on said arc to help hold the arc in said stagnation zone.

(g) said cup-shaped member having a central region of said base disposed within said stagnation zone in which said magnetic means has relatively weak arc rotating abilities,

(h) and means for preventing entry of said upstream arc terminal into said central region.

2. The electric circuit breaker of claim 1 in which the means for preventing entry of said upstream arc terminal into said central region comprises means for causing an auxiliary blast of gas to flow through said central region toward said orifice opening.

3. The electric circuit breaker of claim 1 in which the means for preventing entry of said upstream arc terminal into said central region comprises electrical insulating material located in said central region.

4. The interrupter of claim 1 in which said magnetic means produces an arc rotating force that is relatively strong in the region adjacent the upstream terminal of the arc and is relatively weak in the region adjacent the downstream terminal of the arc, and means for holding the downstream terminal of said arc generally stationary on the downstream one of said electrodes while the upstream terminal of said arc is being rotated.

5. An electric circuit breaker of the axial blast, gas blast type comprising:

(a) a pair of electrodes between which an arc is established during circuit interruption,

(b) means for causing a stream of gas to flow axially of said arc about the periphery thereof,

(c) portions of said gas stream flowing closely adjacent to the upstream one of said electrodes but separating from the surface of said electrode at the downstream face thereof, whereby to define a stagnation zone at said downstream face,

(d) said arc having an upstream terminal that is held captive in said stagnation zone during a circuit-interrupting operation,

(e) said upstream electrode comprising a forward portion having a surface defining said downstream face and a tubular wall portion extending from said forward portion in a direction upstream therefrom,

(f) said forward portion being of an arc resistant refractory metal and most of said wall portion being of a less refractory metal,

(g) said wall portion having a predetermined region upstream from said stagnation zone where said upstream terminal first attaches to said upstream electrode,

(h) an insert of arc resistant refractory metal in said wall portion defining a path extending between said predetermined region and said forward portion to provide a path for the upstream arc terminal to follow in entering said stagnation zone,

(i) said wall portion containing slots circumferentially-spaced around said electrode and having their long dimension extending in a direction longitudinally of said wall portion to restrict the circumferential flow of current through said electrode, and

(j) an adjacent pair of said slots bordering said arc-resistant insert.

6. An electric circuit breaker of the axial-blast, gas blast type comprising:

(a) an upstream and a downstream electrode between which an arc is established during circuit interruption,

(b) an orifice having an opening through which said arc is adapted to extend when present between said electrodes,

(c) means for causing a stream of gas to pass through said orifice opening axially of the arc about the periphery of said arc,

(d) portions of said gas stream flowing closely adjacent to the outer periphery of said upstream electrode but separating from the surface of said upstream electrode in a region facing the orifice opening, whereby to define a stagnation zone in said latter region,

(e) said arc having an upstream terminal that is held captive in said stagnation zone during a circuit interrupting operation,

(f) and magnetic means for rotating said upstream terminal about a point on said upstream electrode while said upstream arc terminal is held captive in said stagnation zone,

(f') said upstream electrode comprising a generally cup-shaped member surrounding said magnetic means with the base of said cup-shaped member facing downstream with said stagnation zone positioned on said base, means for forcing current flowing through said cup-shaped member to an arc terminal in said stagnation zone to flow from the outer periphery of said cup-shaped member radially inwardly, thereby developing a radially-inwardly acting magnetic force on said arc to help hold the arc in said stagnation zone,

(g) said cup-shaped member having a central region of said base disposed within said stagnation zone in which said magnetic means has relatively weak arc-rotating abilities,

(h) and means for preventing entry of said upstream arc terminal into said central region,

(i) said magnetic means being confined to a location immediately adjacent said upstream electrode so as to produce an arc rotating magnetic field that is relatively strong in the region adjacent said upstream arc terminal and is relatively weak in the region adjacent the downstream arc terminal,

(j) and means for holding the downstream terminal of said arc generally stationary on said downstream electrode while said upstream terminal is being rotated.

7. An electric circuit breaker of the axial blast, gas blast type comprising:

(a) a pair of electrodes between which an arc is established during circuit interruption,

(b) an orifice having an opening through which said arc is adapted to extend when present between said electrodes,

(c) means for causing a stream of gas to pass through said orifice opening axially of the arc about the periphery of said arc,

(d) portions of said gas stream flowing closely adjacent to the electrode located upstream from said orifice but separating from the surface of said electrode in a region facing the orifice opening, whereby to define a stagnation zone in said latter region,

(e) said arc having an upstream terminal that is held captive in said stagnation zone during a circuit interrupting operation,

(f) magnetic means for rotating said upstream terminal about a point on said upstream electrode while said upstream arc terminal is held captive in said stagnation zone,

(g) said upstream electrode having a central region disposed within said stagnation zone in which said magnetic means has relatively weak arc rotating abilities,

(h) and means for preventing entry of said upstream arc terminal into said central region,

(i) said upstream electrode comprising a forward portion that is located within said stagnation zone and a tubular wall portion extending from said forward portion in a direction upstream therefrom.

(j) said forward portion being of an arc resistant refractory metal and most of said wall portion being of a less refractory metal,

(k) said wall portion having a predetermined region upstream from said stagnation zone where said upstream arc terminal first attached to said upstream electrode,

(l) an insert of arc-resistant refractory metal in said wall portion defining a path extending between said predetermined region and said forward portion to provide a path for the upstream arc terminal to follow in entering said stagnation zone.

(m) said wall portion containing slots circumferentially spaced about said electrode and having their long dimension extending in a direction longitudinally of said wall portion to restrict the circumferential flow of current through said electrode, and

(n) an adjacent pair of said slots bordering said arc-resistant insert.

8. An electric circuit breaker of the axial blast, gas blast type comprising:

(a) a pair of electrodes between which an arc is established during circuit interruption,

(b) an orifice having an opening through which said arc is adapted to extend when present between said electrodes,

(c) means for causing a stream of gas to pass through said orifice opening axially of the arc about the periphery of said arc,

(d) portions of said gas stream flowing closely adjacent to the electrode located upstream from said orifice but separating from the surface of said electrode in a region facing the orifice opening, whereby to define a stagnation zone in said latter region,

(e) said arc having an upstream terminal that is held captive in said stagnation zone during a circuit interrupting operation,

(f) magnetic means for rotating said upstream terminal about a point on said upstream electrode while said upstream arc terminal is held captive in said stagnation zone,

(g) said upstream electrode having a central region disposed within said stagnation zone in which said magnetic means has relatively weak arc rotating abilities,

(h) and means for preventing entry of said upstream arc terminal into said central region,

(i) said upstream electrode being of a hollow construction and said magnetic means comprising a coil located within said hollow electrode,

(j) a conductive stud projecting into said hollow upstream electrode from the back thereof for supporting said electrode and for carrying current to and from said electrode, and

(k) said coil encircling said stud and being connected at one end to the forward end of said stud and at its opposite end to a portion of said electrode located upstream from said stagnation zone.

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