Feb. 24, 1953 E. SALZER 2,629,798

CROSS AIR BLAST CIRCUIT BREAKER

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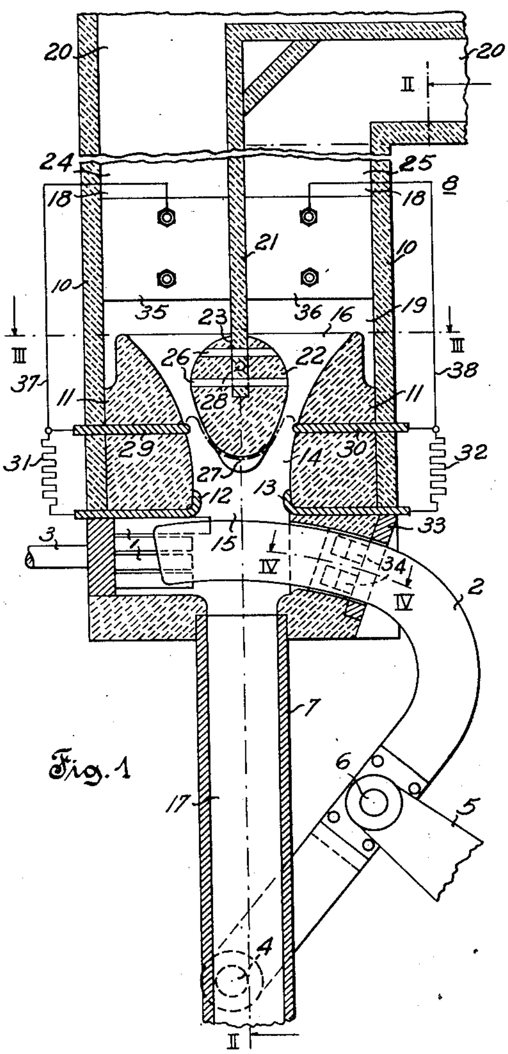

Fig. 1

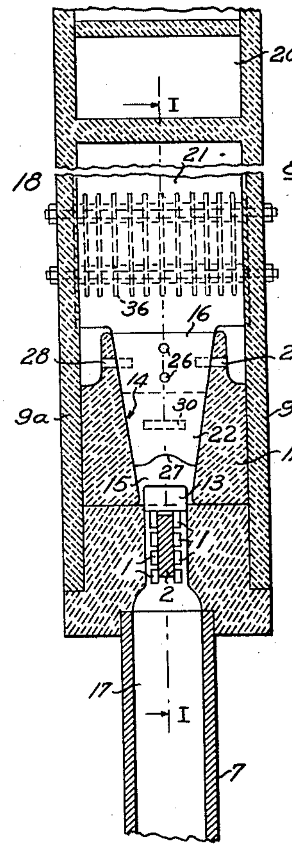

Fig. 2

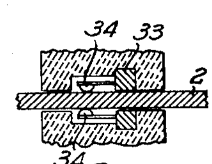

Fig. 4

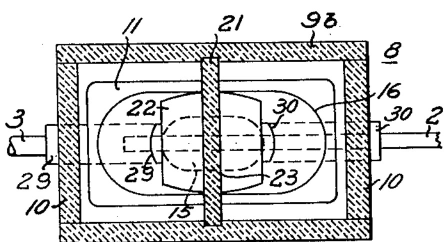

Fig. 3

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CROSS AIR BLAST CIRCUIT BREAKER

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11 Claims. (Cl. 200—148)

My invention relates to gas blast circuit breakers for interrupting high alternating currents, and more particularly air blast circuit breakers.

It has been found that extinction of high current arcs can be achieved most efficiently where the arc incident upon separation of a pair of relatively movable contacts is moved by an arc-extinguishing blast of gas against an arc-restraining barrier of insulating material. In such an arrangement the arc is caused to form two loops, one on each side of the arc-restraining barrier. The interrupting efficiency of such a structure is probably primarily due to the fact that the gas blast acts on a plurality of arc loops and that the portion of the arc which is urged by the blast into engagement with the arc-restraining barrier is effectively deionized by surface action thereof. That surface action can be enhanced by making the arc-restraining barrier of an insulating material, preferably of organic nature, evolving large amounts of gases or vapors when exposed to the heat of the arc, resulting in cooling and dilution of the arc stream into which they are caused to diffuse.

These advantageous features are, however, in part offset by the fact that the arc length is rapidly increased by the arc-extinguishing blast during the time elapsing between arc initiation and arc extinction. That rapid increase of the length of the arc results in an increase of the total arc energy or switch energy defined by the equation

$$W=\int_{t=0}^{t=T} e_a.i_a.dt$$

wherein e_a is the arc voltage which increases as the arc length increases, i_a the arc current and T the time of arc extinction.

It is therefore one object of my invention to provide a circuit breaker of the gas blast type wherein the surface action of an arc-restraining barrier of insulating material plays a major part in the interrupting process and wherein the length of each of the two arc loops which are formed on opposite sides of the arc-restraining barrier is limited, thus limiting the total arc energy involved in the process of circuit interruption.

It has been found that extinction of arcs in gas blast circuit breakers can be considerably facilitated by the provision of probe electrodes and resistors for shunting predetermined arc sections. If the ohmic value of such a shunt resistor is small compared to the resistance of the arc section which is shunted by it, a relatively large portion of the arc current flows through the shunt

resistor and the resulting decrease of current in the shunted arc section is correspondingly high. The arc section carrying but a small portion of the total arc current is then rapidly extinguished under the action of the gas blast. Upon extinction of such an arc section the resistor is serially related to the remaining portion of the arc, thus limiting the arc current.

The smaller the ohmic value of a shunt resistor, the easier it is to extinguish by the blast of gas the section of the arc which is shunted by the resistor, but the less effective is the action of the resistor when it is subsequently arranged in series with the remaining portion of the arc. Conversely, where the ohmic value of a shunt resistor is relatively large, the resulting decrease of current in the shunted arc section is relatively small, and hence it is relatively difficult to extinguish the shunted section of the arc by the blast of gas. Whenever this can be achieved the resistor, which is then serially related to the remaining portion of the arc, will be relatively effective owing to its relatively high ohmic value.

It is thus apparent that provision of shunt resistors having either a relatively low ohmic value, or a relatively high ohmic value, is subject to serious limitations.

It is therefore another object of my invention to provide a circuit breaker of the gas blast type permitting insertion of a relatively large total amount of resistance into the circuit in two consecutive steps each involving but a relatively small amount of resistance wherein each such step comprises elimination, by a shunt resistor, of one of the arc sections, relatively remote from the surfaces of the arc-restraining barrier, of the two arc loops situated on opposite sides of said barrier, and wherein a residual or low current arc extending transversely across the upstream end of the arc-restraining barrier is allowed to subsist until after elimination of said sections of the arc, and wherein said residual arc extending transversely across the upstream end of the arc-restraining barrier forms the portion of the arc last to be extinguished by the blast.

In gas blast circuit breakers wherein the arc is moved against an arc-restraining barrier and is lapped around it by a blast of gas directed substantially transversely to the direction of contact separation, the arcing zone at the time of arc extinction is situated far downstream from the point where the arc was initiated. Metal vapors which are evolved from the hot arc terminals and electrons which are emitted from the arc terminal forming the cathode of the arc discharge are transferred by the blast in downstream direction into the arcing zone and greatly impair the dielectric recovery thereof.

It is therefore another object of my invention to provide a circuit breaker of the cross-gas-blast type precluding or greatly limiting contamination of the downstream arcing zone by metal vapors evolved from and electrons emitted from any arc terminals situated upstream from the arcing zone.

In gas blast circuit breakers comprising an arc chute wherein the arc is moved against an arc-restraining barrier and lapped around it by an arc-extinguishing blast of gas directed substantially transversely to the direction of contact separation, the amount of ionization within the two blast passages located on opposite sides of the arc-restraining barrier depends, among other factors, upon the length of the arc loop within each passage and upon the number of arc roots or arc terminals located in each passage or upstream of the passage and feeding arc products into the passage. Under otherwise similar conditions, the amount of ionization within each blast passage tends to be the smaller, the shorter the length of the arc loop within the passage. The amount of ionization within the arcing zone of each blast passage tends to be relatively small where the number of arc roots or arc terminals is minimized and where the arc roots or arc terminals are located in such a way as to minimize diffusion of arc products evolved therefrom into the arcing zone.

It is therefore a further object of my invention to provide a circuit breaker of the cross-gas-blast type wherein portions of the arc loops formed on opposite sides of the arc-restraining barrier are eliminated in the early stages of the interrupting process, resulting in a shortened arc path which is being deionized to the point of final arc extinction in the ultimate stages of the interrupting process without being seriously contaminated by evolution of metal vapors and by thermionic emission from any arc terminal located at any point upstream from the arc path.

The arc in a cross-gas-blast circuit breaker comprises two critical portions. One of these portions is the arc section situated immediately adjacent the stationary contact where there is a cloud of metal vapors evolved and of electrons emitted from the stationary contact. The other of these portions is the arc section situated immediately adjacent the movable contact where the atmosphere is likewise electrically contaminated. This second critical portion is situated closest to the opening provided in the arc chute for withdrawal therefrom of the movable contact, and the hot arc products resulting from that second critical portion of the arc have a certain tendency to leak out from the arc chute through said opening.

It is therefore another object of my invention to provide a circuit breaker of the cross-gas-blast type wherein the arc is eliminated in three consecutive steps comprising elimination of the section of the arc immediately adjacent the stationary contact, subsequent elimination of the section of the arc immediately adjacent the movable contact, and finally elimination of an intermediate substantially V-shaped arc section extending from one side of the arc-restraining barrier transversely across the upstream edge portion thereof to the other side of the arc-restraining barrier.

In a gas blast circuit breaker wherein the combined action of the arc-extinguishing blast and

of the arc-extinguishing structure is sufficiently effective in building up the dielectric strength of the arc gap after current zeros to preclude any subsequent gap breakdown by the rising recovery voltage, there is relatively little need to rely on the insertion of resistance into the circuit during the interrupting process. In such cases resistance switching may be considered as a safety factor rather than a vital feature of the circuit breaker. Under such circumstances resistors can be used which have a relatively small ohmic value which, in turn, minimizes possible failure of proper transfer of the arc current to the resistor.

It is therefore one of the objects of my invention to provide a circuit breaker of the gas blast type having one or more shunting resistors the resistances of which are sufficiently low to effect rapid and reliable extinction of the respective arc section which is shunted by them and which circuit breaker has a large inherent interrupting capacity sufficient to clear short circuit currents though not very much reduced by previous insertion of resistance into the circuit.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

Referring to the drawings,

Fig. 1 is an elevational, sectional view taken along plane I—I of Fig. 2 of a medium high voltage cross-air-blast circuit breaker embodying my invention in the closed circuit position thereof;

Fig. 2 is a cross-section along the plane II—II of Fig. 1;

Fig. 3 is a cross-section along the plane III—III of Fig. 1; and

Fig. 4 is a cross-section along the plane IV—IV of Fig. 1.

The circuit breaker comprises essentially relatively movable contacts **1** and **2**. The stationary contact **1** is formed by finger contacts and the movable contact **2** is a substantially sickle shaped blade contact. Stationary contact **1** is connected to terminal **3** and movable contact **2** is connected to a terminal not shown in the drawing. Movable contact **2** is hingedly supported at **4**. Hinge structure **4** may be adapted to carry current from the terminal member not shown to blade contact **2**. Operating lever **5** is hinged at **6** to contact blade **2**. Pulling lever **5** in a downward direction results in rotation of blade contact **2** in a clockwise direction about hinge **4** and disengagement of contact **2** from contact fingers **1**. Pushing lever **5** in an upward direction results in a similar counterclockwise rotation of blade contact **2** and engagement of blade contact **2** by contact fingers **1**.

Blast tube **7** connects the arc chute which has been generally indicated by reference sign **8** with a tank (not shown) wherein a supply of arc extinguishing gas as, for instance, compressed air at a pressure ranging from 150–250 lbs. per square inch, is stored. Arc chute **8** comprises a front plate **9**_a_, a back plate **9**_b_, side plates **10** and a nozzle member **11**. Nozzle member **11** is made of an insulating material that evolves relatively large amounts of gaseous products when exposed to the heat of the arc as, for instance, hard fiber. Nozzle member **11** may be moulded, if desired, from a compound consisting of a mixture of cement and asbestos. Such a nozzle member will evolve fairly large amounts of gaseous products when exposed to the heat of the arc, the amount of gas evolved being, however, smaller than in the case of a nozzle member made of fiber or of a suitable synthetic resin as, for instance, a carbamide resin. A pair of arc runners or arc horns 12, 13 is arranged at the entrance of nozzle 11 a little downstream from the downstream edge of blade contact 2. Arc horns 12 and 13 are aligned in the direction of separation of contacts 1 and 2 and arranged on opposite sides of nozzle member 11. Their purpose is to cause rapid movement of any arc which is drawn between contacts 1 and 2 into nozzle passage 14 which is defined by nozzle member 11.

As can best be seen from Fig. 2, the area exposed to flow of nozzle member 11 increases all the way from intake 15 to outlet 16. Fig. 1 shows that the rate of increase of the area exposed to flow or cross-section of passage 14 is much larger toward outlet 16 than close to inlet 15.

It will be observed that passage 17 defined by blast tube 7 and passage 14 defined by nozzle member 11 are coaxial, while the arc-extinguishing blast through passages 14 and 17 is directed transversely to the direction of separation of contacts 1 and 2.

The arc products which are formed within nozzle passage 14 are cooled in a chamber 18 situated downstream from passage 14.

Nozzle portion 11 has a relatively small average area exposed to flow, and the entrance or inlet 15 and the exhaust or outlet 16 thereof are spaced a relatively small distance apart from each other. Cooling chamber 18 has a relatively large area exposed to flow, and an entrance portion 19 and an exhaust portion 20 which are spaced a relatively large distance apart from each other.

The arc-restraining barrier 21 of heat-resisting insulating material is arranged in cooling chamber 18 and protrudes into nozzle passage 14 defined by nozzle member 11. Barrier 21 is arranged transversely to the direction of separation of contacts 1 and 2. The upstream end of barrier 21 is formed by a member 22 of organic insulating material which evolves relatively large amounts of gas when exposed to the heat of the arc, e. g. hard fiber. It will be noted that the portion of member 22 engaged by the arc increases in width in downstream direction to provide an effective surface in interaction between the arc and member 22. Member 22 is provided with a groove 23 receiving the plate-shaped portion of barrier 21 which subdivides cooling chamber 18 into two separate passages 24, 25. The plate-shaped portion of barrier 21 and the upstream barrier member 22 are secured together by means of pins 26 which are made of insulating material as, for instance, hard fiber. The upstream arc-receiving edge of barrier 21 is provided with a shallow notch 27 which tends to prevent lateral movement of the section of the arc which is lapped around member 22 of barrier 21. Member 22 of barrier 21 is secured to nozzle member 11 by means of pins 28, as can best be seen in Fig. 2.

Single probe electrodes 29 and 30 are arranged on opposite sides of barrier 21 and barrier member 22, respectively. Probe electrodes 29, 30 are so insulated from each other as to be capable to be at a sufficiently different potential to form terminals for an arc extending therebetween. Probe electrodes 29 and 30 are formed by plates arranged substantially transversely to the arc-extinguishing blast and having arc-engaging edges which project into nozzle passage 14. The arc terminals formed on probe electrode plates 29, 30 have a certain tendency to move to the downstream surfaces of said plates, i. e. their surfaces which are not exposed to the blast. The arc terminals will stay there, until complete and final extinction of the arc has been achieved, since they are precluded from moving in downstream direction. It is therefore apparent that the terminal-forming points of probe electrodes 29 and 30 are located downstream from the upstream end of barrier 21, i. e. downstream from the upstream end of barrier member 22. On the other hand, the terminal-forming points of probe electrodes 29 and 30 are located upstream from the downstream end or exhaust 16 of nozzle passage 14.

Probe electrodes 29 and arc horn 12 are connected by a shunt 31. Similarly, probe electrode 30 and arc horn 13 are connected by a shunt 32.

Shunts 31 and 32 may have virtually zero resistance, or one of them may have virtually zero resistance while the other may be constituted by a resistor having an appreciable resistance, or both of them may be constituted by resistors having an appreciable judiciously selected resistance. The operating characteristics of the circuit breaker differ depending upon which of the above alternatives is being adopted, and depending upon which ohmic value, or ohmic values, is being given to one or both of the resistors. This affords a great flexibility which can be achieved with a minimum of changes.

Arc horn 12 is conductively connected to stationary finger contacts 1. In a similar way, arc horn 13 is conductively connected to movable blade contact 2. The conductive connection between arc horn 13 and blade contact 2 comprises a metallic frame structure 33 supporting sets of contacts 34 arranged on opposite sides of and engaging blade contact 2.

Stacks 35, 36 of spaced metal plates are arranged in passages 24 and 25, respectively, for increasing the rate of cooling of the products of arcing flowing past said stacks. Stack 35 is conductively connected by conductor 37 to probe electrode 29 and by shunt 31 to stationary contact 1. Similarly, stack 36 is conductively connected by conductor 38 to probe electrode 30 and by shunt 32, frame 33 and contacts 34 to movable blade contact 2. Conductors 37 and 38 constitute evidently a second pair of shunts in addition to the pair of shunts 31, 32.

The arc formed upon separation of contacts 1 and 2 is urged into nozzle passage 14 by a blast of gas rushing through blast tube 7. The arc terminal formed on the stationary contact finger situated farthest downstream and projecting farthest into the blast is immediately transferred to arc horn 12. The other arc terminal which is formed on blade contact 2 is moved to the right, as viewed in Fig. 1. As soon as the arc loop engages probe electrode 29, the section of the arc extending between arc horn 12 and probe electrode 29 will be shunted, and rapidly extinguished hereafter. Vaporization of the metal of which arc horn 12 is made and emission of electrons from arc horn 12 are stopped almost instantly upon transfer of the entire arc current to shunt 31 and probe electrode 29. From then on probe electrode 29 forms one of the terminals of the main arc which extends from probe electrode 29 transversely across barrier member 22 to movable blade contact 2 which forms the other arc terminal. As soon as the arc loop on the right side of barrier member 22, as viewed in

Fig. 1, engages both arc horn 13 and probe electrode 30, the section of the arc shunted by shunt 32 tends to become unstale and will be rapidly extinguished thereafter by the arc-extinguishing blast.

Upon shunting and extinction of the arc section extending between arc horn 13 and probe electrode 30, the current path through the circuit breaker is as follows: terminal element 3, stationary finger contacts 1, arc horn 12, shunt 31 and probe electrode 29. The gaseous current path begins at the arc termianl on probe electrode 29 and extends from there in upstream direction, then transversely across the arc-restraining edge of barrier 21 or barrier member 22, respectively, and then in downstream direction to probe electrode 30, where the second portion of the metallic current path begins. That portion includes probe electrode 30, shunt 32, metal frame 33, stationary contacts 34 and sickle shaped blade contact 2. Complete interruption of the circuit is achieved when the section of the arc extending between probe electrodes 29 and 30 has been extinguished. This section of the arc is particularly vulnerable because it is subjected to the combined action of the arc-extinguishing blast and to the flow of gaseous products which are evolved under the heat of the arc from member 22 of barrier 21. Moreover, and this is particularly important, there is no arc root or arc terminal situated at any point upstream from the section of the arc extending between probe electrodes 29 and 30 and lapped around member 22 and, therefore, there is no precontamination of the blast which acts upon that arc section by products of arcing formed at any upstream arc root or arc terminal. Since the section of the arc which is lapped around member 22 is situated upstream from the arc roots or arc terminals formed on probe electrodes 29 and 30, contamination of that arc section by products of arcing formed on either arc root or arc terminal is minimized. Electrons which are emitted from either of both probe electrodes 29, 30 are subject to a strong tendency to flow with the arc-extinguishing blast in a downstream direction and out of passage 14 into cooling chamber 18, rather than against the arc-extinguishing blast in an upstream direction transversely across member 22 and thence to the other probe electrode. Owing to these facts the dielectric recovery along the upstream wedge-shaped end of barrier 21 will be relatively rapid, resulting in great interrupting efficiency.

It has been pointed out above that the probe electrodes 29 and 30 must be insulated from each other in such a way as to cause the path of least resistance of any arc section interconnecting said probe electrodes to extend transversely across the upstream edge of barrier 21. If pins 26 were made of metal rather than insulating material, this is likely to cause such lowering of the insulation level between probe electrodes 29 and 30 and such change of the electric field or potential distribution between said probe electrodes that the path of least resistance of any arc section interconnecting probe electrodes 29 and 30 would extend from probe electrode 29 to the left end of one of the pins 26 and from the right end thereof to probe electrode 30. Therefore, if pins 26 were made of metal, the section of the arc lapped around the upstream edge portion of member 22 would be shunted by two serially related arcs, one extending from probe electrode 29 to one of pins 26 and the other from the one of pins 26 to probe electrode 30. This would result in unstability and rapid extinction of the arc section lapped transversely across the upstream edge of member 22. Upon extinction of that arc section the current would be carried solely by the two serially related arcs from probe electrode 29 to pin 26 and from pin 26 to probe electrode 30. Extinction of these two arcs would involve rather unfavorable conditions as virtually complete elimination of the deionizing surface action of barrier member 22 and an increase of the number of arc terminals from two to four and consequent contamination of the zones of both arcs by metal vapors and other arc products formed at points situated upstream from the arcing zones of the two arcs. The proper insulation level between probe electrodes 29, 30 is, therefore, a crucial factor and an undue reduction of the insulation level between said probe electrodes will materially effect the mode of operation and the interrupting efficiency of the circuit breaker.

In order to obtain the desired operating characteristics, including an arc section last to be extinguished extending transversely across the upstream edge portion of the arc-restraining insulating barrier 21, that barrier should extend from nozzle member 11 to a considerable length in downstream direction. The length of barrier 21 must be sufficient to preclude a transfer of the arc section which is urged by the arc-extinguishing blast into engagement with the upstream edge of barrier 21 to and transversely across the downstream edge thereof.

Assuming that there is a sufficiently high insulation level between the probes 29 and 30 but that, for one reason or another, the arc section last to be extinguished extending transversely across member 22 is allowed to subsist for some time. Under such conditions, the two blasts of gas on either side of nozzle passage 14 will cause continued elongation of the arc. If sufficient resistance has been introduced into the circuit by means of shunts 31 and 32, as should normally be done, continued arc elongation is not likely to result in excessive arc energy. But where the ohmic value of shunts 31, 32 is very small, the arc should not be allowed to elongate freely. Shunts 37 and 38 are provided for limiting the elongation of the arc section extending between the probe electrodes 29 and 30 and being lapped transversely across barrier member 22. When the arc-extinguishing blast on the left side of nozzle passage 14 causes the arc to loop until it engages the stack 35 of cooling plates, the section of the arc extending between probe electrode 29 and stack 35 will be short-circuited by shunt 37 and thus instantly eliminated. This results in a transfer to stack 35 of the terminal of the arc which was heretofore on probe electrode 29. Similarly, when the arc-extinguishing blast on the right side of nozzle passage 14 causes the arc to loop until it engages stack 36 of cooling plates, the section of the arc extending between probe electrode 30 and stack 36 will be short-circuited by shunt 38 and thus instantly eliminated. This results in a transfer to stack 36 of the terminal of the arc which was heretofore on probe electrode 30. As a result of this process, another inverted V-shaped arc is formed extending transversely across the upstream end of barrier 21 and having its terminals situated at points downstream from any point of the arc path.

The longer an arc section is allowed to persist in a circuit breaker, the more difficult it may be to extinguish it thereafter. For this reason it might prove to be desirable in a given application to provide shunt 37 in addition to shunts 31 and 32, while shunt 38 may be dispensed with.

Where the ohmic values of shunts 31 and 32 are not too small to limit short-circuit currents to an appreciable extent, shunt 37 may likewise be dispensed with.

Provision of shunts 37 and 38 results in that a relatively high voltage prevails across barrier 21 after circuit interruption has been achieved. Hence it is necessary to take precautions to preclude at any time any electric breakdown across barrier 21. Since this entails additional expense, it is optional to dispense with at least one of shunts 37 and 38.

While I have illustrated and described as a preferred embodiment of my invention a circuit breaker wherein the nozzle portion and the cooling chamber are clearly distinguishable from each other, it will be apparent that my invention is likewise applicable to circuit breakers comprising arc chutes of fish-tail shape wherein the nozzle portion merges gradually into the cooling chamber.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various modifications and changes may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. A gas blast circuit breaker for interrupting high currents in alternating current circuits comprising a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof; a nozzle structure of insulating material arranged adjacent said contacts substantially transversely to the direction of contact separation; means for producing an arc-extinguishing blast of gas transversely across the gap formed upon separation of said contacts and axially through said nozzle structure; means defining a cooling chamber arranged downstream from said nozzle structure for receiving the blast escaping from said nozzle structure, the average cross sectional area of said cooling chamber being large compared to the average cross sectional area of said nozzle structure and the length of said cooling chamber being large compared to the length of said nozzle structure; an arc-restraining barrier of heat-resistant insulating material arranged transversely to the direction of contact separation and projecting from said cooling chamber into said nozzle structure; a pair of arc horns aligned in the direction of contact separation each arranged on opposite sides of said nozzle structure for causing rapid movement of said arc into said nozzle structure; a pair of probe electrodes each on an opposite side of said barrier downstream from the point thereof situated highest upstream; a pair of shunts each connecting one of said pair of contacts and one of said probe electrodes for eliminating the sections of the arc on opposite sides of said barrier relatively remote from the surfaces thereof while an arc section extending between said probe electrodes still persists, at least one of said pair of shunts being formed by a resistor for inserting resistance into the circuit under interruption prior to complete extinction of said arc, and means for insulating said probe electrodes from each other in such a way as to cause the path of least resistance of any arc section formed between said pair of probe electrodes to extend transversely across the upstream end of said barrier.

2. In a gas blast circuit breaker for interrupting high currents in alternating current circuits, a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof; means for producing an arc-extinguishing blast of gas adjacent said pair of contacts substantially transversely to the direction of contact separation; an arc chute comprising a nozzle portion arranged substantially in the direction of said blast and a chamber for cooling the arc products escaping from said nozzle portion, said nozzle portion having a relatively small average area exposed to flow and an entrance portion and an exhaust portion spaced a relatively small distance apart from each other, and said cooling chamber having a relatively large average area exposed to flow and an entrance portion and an exhaust portion spaced a relatively large distance apart from each other; an arc-restraining barrier of heat-resistant insulating material in said cooling chamber protruding into said nozzle portion and arranged transversely to the direction of contact separation, the portion of said barrier engaged by said arc increasing in width in downstream direction to provide an effective surface of interaction between said arc and said barrier; a pair of arc runners each connected to one of said contacts and extending into said nozzle portion to transfer said arc from said contacts into said nozzle portion, the downstream ends of said arc runners being situated within said nozzle portion upstream from said chamber for cooling the arc products and upstream from the upstream edge portion of said barrier, the only metal parts arranged in said nozzle portion in addition to said arc runners being single probe electrodes on opposite sides of said barrier, said probe electrodes being so insulated from each other as to be capable to be at a different potential to form a pair of terminals for an arc extending therebetween, the terminal-forming points of said probe electrodes being located downstream from the upstream end of said barrier; a pair of shunts each connecting one of said pair of contacts to one of said probe electrodes for causing extinction of the sections of said arc situated immediately adjacent said pair of contacts prior to extinction of the section of said arc extending between said probe electrodes; and means for so distributing the potential across the gap formed between said probe electrodes as to cause the arc path of least resistance therebetween to extend transversely across said upstream end of said barrier to preclude formation of any other current path across said gap.

3. In a gas blast circuit breaker for interrupting high currents in alternating current circuits, a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof; means for producing an arc-extinguishing blast of gas adjacent said pair of contacts transversely to the direction of contact separation; an arc chute comprising a nozzle portion arranged substantially in the direction of said blast and a chamber for cooling the arc products escaping from said nozzle portion, said nozzle portion having a relatively small average area exposed to flow and an entrance portion and an

exhaust portion spaced a relatively small distance apart from each other, and said cooling chamber having a relatively large average area exposed to flow and an entrance portion and an exhaust portion spaced a relatively large distance apart from each other; a single arc-restraining barrier of heat-resistant insulating material in said cooling chamber protruding into said nozzle portion and arranged transversely to the direction of contact separation; a pair of arc runners each connected to one of said contacts and extending into said nozzle portion to transfer said arc from said contacts into said nozzle portion, the downstream ends of said arc runners being situated within said nozzle portion upstream from said chamber for cooling the arc products and upstream from the upstream edge portion of said barrier; a pair of probe electrodes each arranged on an opposite side of said barrier transversely to the direction of said blast between said entrance portion and said exhaust portion of said nozzle at a point located downstream from the upstream end of said barrier, said pair of probe electrodes being insulated from each other in such a way as to cause the path of least resistance of any arc section interconnecting said pair of probe electrodes to extend transversely across said upstream end of said barrier; and a pair of shunts each connecting one of said pair of contacts to one of said pair of probe electrodes.

4. An alternating current circuit interrupter comprising a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof, an arc restraining insulating barrier arranged substantially edgewise with respect to said arc, means for producing an arc extinguishing blast of gas substantially transversely to the direction of contact separation, arc runners arranged adjacent said contacts and conductively connected thereto for transferring said arc from the region of arc initiation to a point downstream therefrom, a pair of probe electrodes arranged on opposite sides of said barrier downstream from said arc runners and from the upstream edge of said barrier, said probe electrodes being insulated from each other in such a way as to cause the path of least resistance of any arc section interconnecting said probe electrodes to extend transversely across said upstream edge of said barrier, and a pair of shunts each connecting one of said arc runners and one of said probe electrodes for eliminating the sections of the arc situated on opposite sides of said barrier relatively remote from the surface thereof.

5. An alternating current circuit interrupter comprising a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof, an arc restraining insulating barrier arranged substantially edgewise with respect to said arc, means for producing an arc extinguishing blast of gas substantially transversely to the direction of contact separation, arc runners arranged adjacent said contacts and conductively connected thereto for transferring said arc from the region of arc initiation to a point downstream therefrom, a pair of probe electrodes arranged on opposite sides of said barrier downstream from said arc runners and from the upstream edge of said barrier, said probe electrodes being insulated from each other in such a way as to cause the path of least resistance of any arc section interconnecting said probe electrodes to extend transversely across said upstream edge of said barrier, and a pair of shunts each connecting one of said arc runners and one of said probe electrodes for eliminating the sections of the arc situated on opposite sides of said barrier relatively remote from the surface thereof prior to extinction of the section of the arc extending from one of said probe electrodes in upstream direction to and transversely across said upstream edge of said barrier and thence in downstream direction to the other of said probe electrodes.

6. An alternating current circuit interrupter comprising a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof, a nozzle structure of insulating material arranged adjacent said contacts transversely to the direction of contact separation, means for producing an arc extinguishing blast of gas substantially transversely across the gap formed upon separation of said contacts and axially through said nozzle structure, an arc restraining barrier of heat resistant insulating material arranged transversely to the direction of contact separation and projecting into said nozzle structure, arc runners arranged adjacent said contacts and conductively connected thereto for transferring said arc from the region of arc initiation to a point within said nozzle structure, a pair of probe electrodes on opposite sides of said barrier downstream from the point thereof situated highest upstream, a pair of shunts each connecting one of said arc runners and one of said probe electrodes for eliminating the sections of the arc on opposite sides of said barrier relatively remote from the surfaces thereof while an arc section extending between said probe electrodes still persists, at least one of said shunts being formed by a resistor for inserting resistance into the circuit under interruption prior to complete extinction of said arc, and means for insulating said probe electrodes from each other in such a way as to cause the path of least resistance of any arc section formed between said probe electrodes to extend transversely across the upstream end of said barrier, said insulating means including the dielectric integrity of said barrier.

7. An alternating current circuit interrupter comprising a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof, means for producing an arc extinguishing blast of gas adjacent said contacts substantially transversely to the direction of contact separation, an arc chute comprising a nozzle portion arranged substantially in the direction of said blast and a chamber for cooling the arc products escaping from said nozzle portion, said nozzle portion having a relatively small average area exposed to flow and an entrance portion and an exhaust portion spaced a relatively small distance apart from each other, and said cooling chamber having a relatively large average area exposed to flow and an entrance portion and an exhaust portion spaced a relatively large distance from each other, an arc restraining barrier of heat resistant insulating material in said cooling chamber protruding into said nozzle portion and arranged transversely to the direction of contact separation, arc runners arranged adjacent said contacts and conductively connected thereto for transferring said arc from the region of arc initiation to a point within said nozzle, single probe electrodes arranged on opposite sides of said barrier downstream of said arc runners, said probe electrodes being so insulated from each other as to be capable of being at different potentials to form a pair of terminals for an arc

extending therebetween, the terminal forming points of said probe electrodes being located downstream from the upstream end of said barrier and upstream from the downstream end of said nozzle, and a pair of shunts each connecting one of said arc runners to one of said probe electrodes.

8. An alternating current circuit interrupter comprising a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof, an arc chute for receiving said arc, a single insulating barrier arranged within said arc chute adjacent the gap formed upon separation of said contacts, means for producing an arc extinguishing blast of gas substantially parallel to the axis of said barrier for driving said arc against an arc restraining edge portion of said barrier, arc runners arranged adjacent said contacts and conductively connected thereto for transferring said arc from the region of arc initiation to a point within said arc chute, a pair of probe electrodes arranged on opposite sides of said barrier at points located downstream from said arc restraining edge portion, a pair of shunts each connecting one of said contacts to one of said probe electrodes for eliminating the sections of said arc situated on opposite sides of said barrier relatively remote from the surfaces thereof, and means for causing the section of said arc last to be extinguished by said blast to extend from one of said probe electrodes in upstream direction to and transversely across said arc restraining edge portion and thence in downstream direction to the other of said probe electrodes.

9. An alternating current circuit interrupter comprising a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof, means for producing an arc extinguishing blast of gas adjacent said contacts, an arc chute comprising an upstream relatively short and narrow nozzle portion arranged substantially in the direction of said blast and a downstream relatively long and wide cooling portion for reducing the temperature of the products of arcing formed within said nozzle portion, said nozzle portion having a relatively restricted inlet and a widely flaring outlet, a single arc restraining barrier of heat resistant insulating material in said cooling chamber protruding into said nozzle portion and arranged transversely to the direction of contact separation, the portion of said barrier engaged by said arc increasing in width in downstream direction to provide an effective surface of interaction between said arc and said barrier, arc runners arranged adjacent said contacts and conductively connected thereto for transferring said arc from the region of arc initiation to a point within said arc chute, probe electrode means on opposite sides of said barrier consisting of a single pair of probe electrodes separated by said barrier, said probe electrodes being so insulated from each other as to be capable of being at different potentials to form a pair of terminals for an arc extending therebetween, the terminal forming points of said probe electrodes being located downstream from the upstream end of said barrier and between said inlet and said outlet of said nozzle portion, means for so distributing the potential between said probe electrodes as to cause the arc path of least resistance therebetween to extend transversely across the upstream end of said barrier, and means for shunting the sections of said arc extending between said arc runners and said probe electrodes.

10. An alternating current circuit interrupter comprising a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof, means for producing an arc extinguishing blast of gas substantially transversely to the direction of contact separation, an arc chute comprising a nozzle portion arranged substantially in the direction of said blast and a chamber for cooling the products of arcing escaping from said nozzle portion, said nozzle portion consisting of an insulating material evolving relatively large amounts of gas when exposed to the heat of the arc and having a relatively small average area exposed to flow, said cooling chamber having a relatively large average area exposed to flow and by far exceeding the length of said nozzle portion, a single arc restraining barrier of insulating material arranged in said cooling chamber transversely to the direction of contact separation, said barrier being free from any metal masses exposed to arcing and having an upstream portion projecting into said nozzle portion and being provided with an arc restraining notch, arc runners arranged adjacent said contacts and conductively connected thereto for transferring said arc from the region of arc initiation to a point within said nozzle, single probe electrodes on opposite sides of said barrier, said probe electrodes projecting transversely across said nozzle portion with the inner ends thereof projecting into said area of said nozzle portion exposed to flow, said probe electrodes being arranged in spaced relation from said barrier to form an air gap between said barrier and each said probe electrode, said probe electrodes being so insulated from each other as to be capable of being at different potentials and to form a pair of terminals for an arc extending therebetween, the terminal forming points of each said probe electrodes being located in such a way as to be separated from each other by said upstream portion of said barrier, means for so distributing the potential between said probe electrodes as to cause the arc path of least resistance therebetween to extend transversely across said upstream portion of said barrier, and a pair of shunts each interconnecting one of said contacts and one of said probe electrodes.

11. An alternating current circuit interrupter comprising a pair of relatively movable contacts for drawing an arc therebetween upon separation thereof, means for producing an arc extinguishing blast of gas adjacent said contacts transversely to the direction of contact separation, an arc chute comprising a nozzle portion arranged substantially in the direction of said blast and a chamber for cooling the arc products escaping from said nozzle portion, said nozzle portion having a relatively small average area exposed to flow and an entrance portion and an exhaust portion spaced a relatively small distance from each other, and said cooling chamber having a relatively large average area exposed to flow and an entrance portion and an exhaust portion spaced a relatively large distance from each other, a single arc restraining barrier of heat resistant insulating material in said cooling chamber protruding into said nozzle portion and arranged transversely to the direction of contact separation, said barrier being free from any metal masses exposed to arcing, arc runners arranged adjacent said contacts and conductively connected thereto for transferring said arc from the region of arc initiation to a point within said arc chute, single probe elec-

trodes on opposite sides of said barrier, said probe electrodes projecting transversely across said nozzle portion with the inner ends thereof projecting into said area of said nozzle portion exposed to flow, said probe electrodes being arranged in spaced relation from said barrier to form an air gap between said barrier and each said probe electrode, said probe electrodes being so insulated from each other as to be capable of being at different potentials to form a pair of terminals for an arc extending therebetween, the terminal forming points of said probe electrodes being located downstream from the upstream end of said barrier and upstream from the downstream end of said nozzle, and a pair of resistors each connecting one of said pair of contacts and one of said probe electrodes.

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