

June 2, 1942.

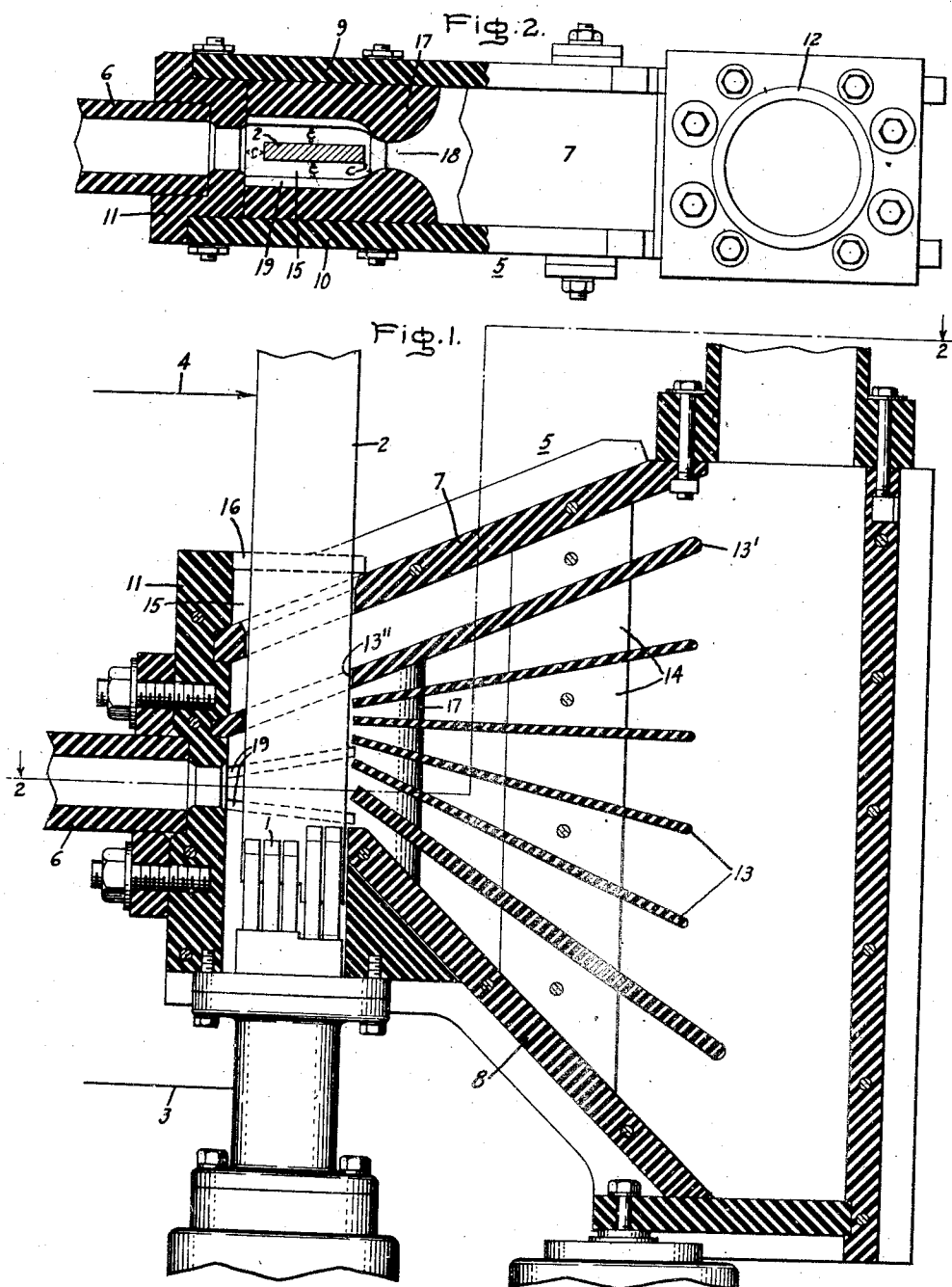
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2,284,856

GAS BLAST ELECTRIC CIRCUIT BREAKER

Filed Aug. 5, 1941

2 Sheets-Sheet 1



Inventor:
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His Attorney.

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Fig. 3.

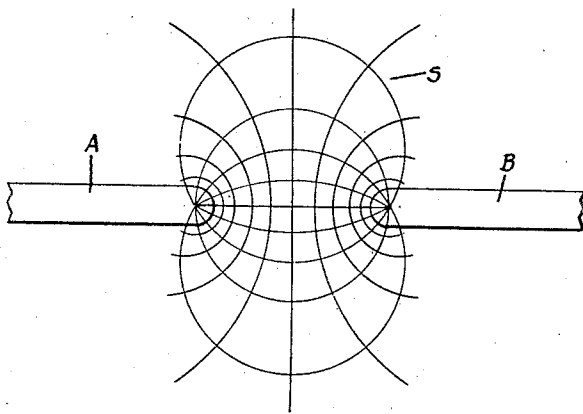


Fig. 4.

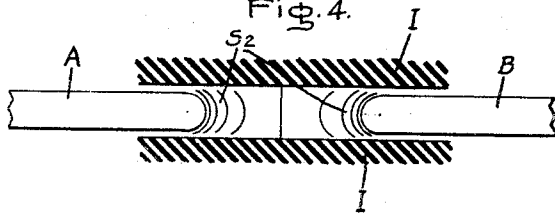
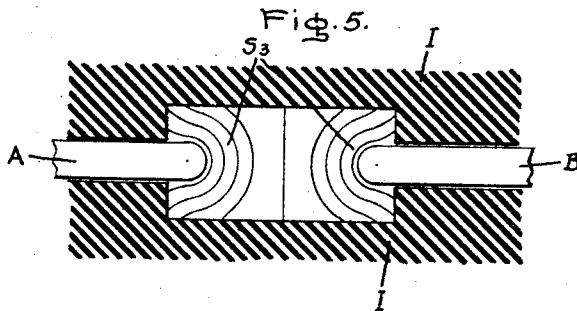


Fig. 5.



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UNITED STATES PATENT OFFICE

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GAS BLAST ELECTRIC CIRCUIT BREAKER

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Application August 5, 1941, Serial No. 405,468

13 Claims. (Cl. 200-148)

My invention relates to gas blast electric circuit breakers, more particularly to those of the "cross-blast" type wherein the arc to be interrupted is formed in an elongated or slot-like insulating arc chamber at the entrance portion of an arc chute and is subjected to a high velocity blast of interrupting gas that is directed through said chamber substantially at right angles to the arc length, and has for its principal object the provision of an improved circuit breaker of the aforesaid cross-blast type that is more effective to interrupt power circuits at comparatively high voltage.

The interruption of large power currents at moderate voltages, such as 15 kv., has been efficiently accomplished by an air-blast circuit breaker of the type above referred to. In this breaker the insulating side walls of the slot-like arc chamber in which a blade contact is movable are fairly closely spaced to insure an intensive application of the air blast. When, however, this breaker is used in circuits of considerably higher voltage, such as 50 kv., serious interrupting difficulties appear and reliable interruption is not obtained. The arc, although it may be interrupted by the gas blast at the first current zero, is often re-ignited by the recovery voltage due to dielectric breakdown at the arc gap.

I have found that the interrupting performance of the cross-blast air circuit breaker can be appreciably improved at higher voltages by designing the arc gap space between the separating contacts so that the maximum electrostatic stress incident to appearance of the recovery voltage across the arc gap is greatly decreased. With this design, the gas blast is better able to maintain sufficient dielectric between the separated contacts to prevent voltage breakdown at the interrupting gap and resulting re-ignition of the arc.

My invention will be more fully set forth in the following description referring to the accompanying drawings, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

Referring to the drawings, Fig. 1 is an elevational view in section of an air circuit breaker of the cross-blast type embodying the present invention, Fig. 2 is a plan view of the circuit breaker shown in Fig. 1, with a portion in section, taken along the line 2-2 of Fig. 1, Fig. 3 is a graphical illustration of the electrostatic field between spaced electrodes in air across which a high voltage is impressed, Fig. 4 is a graphical illustration of the electrostatic stress between the aforesaid electrodes when the intervening gap is a narrow slot defined by an insulating solid, and Fig. 5 is a similar graphical illustration

showing the electrostatic stress between the electrodes when the gap space is appreciably enlarged in all directions transversely of the gap length.

In Fig. 1, there is shown by way of example an air circuit breaker of the cross-blast type in the closed circuit position thereof having relatively movable contacts comprising fixed contact structure 1 and a reciprocally guided rod or blade-like contact 2. The fixed contact is electrically connected as indicated to one line terminal of the breaker at 3 and the blade-like movable contact is also connected as indicated to the other line terminal at 4. The blade contact 2 is movable by suitable actuating means (not shown) along a generally rectilinear path to make and break the circuit with respect to the fixed contact 1 although it will be apparent that the blade may, if desired, be arcuate in form and move longitudinally along an arc instead of a straight line. Also, the cross-sectional shape of the contact 2 may be circular instead of rectangular if desired.

For the purpose of extinguishing the arc formed between the contacts when the power circuit is opened by the breaker, an insulating arc chute 5 is arranged with respect to the contacts so that the arc is drawn at the entrance portion of the chute directly opposite a gas blast supply conduit 6. The conduit 6 is suitably connected through a blast control valve (not shown) to a source of compressed gas, such as air, comprising for example a storage tank and compressor equipment.

The arc chute 5 defines a narrow, diverging space into which the arc is driven and extinguished by the interrupting blast and is formed by diverging end walls 7 and 8 and comparatively closely spaced parallel side walls 9 and 10 together with a bottom wall 11 through which the blast passage extends (Fig. 2). The walls of the chute are composed of a mechanically strong insulating material, such as a molded laminated structure. The exhaust end of the chute is closed except for a laterally extending conduit 12 which directs the heated blast gases away from the circuit breaker proper.

The chute also includes a plurality of insulating arc barriers 13 that are disposed edgewise to the arc path with the barrier width transversely of the arc path so as to form diverging gas passages leading to the exhaust conduit. Spaced cooling plates 14 are located in the path of the hot gases flowing through the chute. The barriers extend fairly close to the arc path as indicated and are composed of a vaporizable insulating material such as hard fibre that does not lose its insulating characteristics in the presence of the arc as disclosed and claimed in an application Serial No. 303,126 (Docket 64,679),

filed November 6, 1939, by D. C. Prince et al. for "Circuit breaking apparatus and method of operating the same," and assigned to the same assignee as the present invention.

The arc chamber or space in which the arc is drawn is formed at the entrance of the chute between the blast supply conduit 6 and the arc barriers 13 and constitutes an elongated chamber 15 having at one end an opening 16 in registry with the movable contact 2 which can move exteriorly of the chute to a safe isolating distance. The barrier 13' extends entirely across the arc chamber for confining the arc flame to the chute interior and has a slot 13'' also in registry with the contact 2. The arc formed between the separated contacts may extend longitudinally of the chamber as is evident from Fig. 1 so as to be in the direct path of the gas blast as it is directed into the chute.

In the cross-blast breakers heretofore used, the chamber 15 was formed as a comparatively narrow slot for receiving the movable contact blade. That is, the design was preferably such that the conducting portions of the blade contact were closely confined by the insulating chamber walls. The gas blast was therefore confined to high velocity flow at the arc path which was considered essential for interrupting large power currents. This design in fact, is very successful in interrupting power circuits at about 15 kv. However, where appreciably higher voltages are involved, reliable interruption is not obtained notwithstanding the use of high blast pressures. Unexpected breakdown of the gap dielectric between the separated contacts occurs and failure of the breaker results.

What I believe to be the correct analysis of the breaker failure is as follows: When a high voltage is impressed across two separated electrodes immersed in a substantially unconfined fluid dielectric such as air, the electrostatic stress can be diagrammatically illustrated as shown by Fig. 3. Here the spaced electrodes A and B define a gap in air dielectric across which is impressed a high voltage such as 50 kv. The distribution of electrostatic stress is indicated by the equipotential stress lines S. It will be noted that in this case there is no high degree of concentration of the electrostatic field, particularly in the space between the contacts.

Now let it be assumed that the gap between the electrodes A and B is confined by closely spaced solid insulating walls I as illustrated by Fig. 4. The insulating walls are shown as quite closely spaced with respect to the electrodes A and B to form a narrow slot-like space for the gap.

The insulating walls may be of a mechanically strong material such as horn fibre for example. In this case, the difference between the dielectric constants of the air and the solid insulating material is so great that the electrostatic stress in the gap is greatly increased at the surfaces of the electrodes as indicated at S2. For example, the dielectric constant of horn fibre as compared with air is from 2.5 to 5.0. In other words, with a given voltage impressed across the electrodes A and B, the gap dielectric shown by Fig. 4 is much more liable to voltage breakdown than that shown by Fig. 3.

In accordance with my invention, I provide an arc gap in air of such size and shape that the high degree of concentration of electrostatic stress indicated by Fig. 4 is avoided. In Fig. 5 there is shown an arrangement embodying this

principle. The spaced electrodes A and B in this case also define a gap enclosed by solid insulating walls I of the character indicated in Fig. 4. However, the gap is not closely confined and the electrostatic stress at the electrodes is less concentrated as indicated at S3. The air, although having a dielectric constant much less than the solid insulating material nevertheless is less subject to voltage breakdown when the air gap space is appreciably enlarged, particularly with respect to the transverse dimensions of the arc path space, as illustrated by Fig. 5.

In the practical embodiment of my invention, the gap space, i. e., the arc chamber, is shaped as shown by Fig. 2. The side walls of the arc chamber are formed by a pair of insulating members 17 composed of horn fibre or the like and shaped so as to form a more restricted blast passage at 18 beyond the upper edge of the blade contact. The restricted passage at 18 is designed so that an effective gas blast is obtained together with economical use of the interrupting gas. The conducting sides of the blade contact are, however, approximately equally spaced from the side and end walls of the comparatively spacious arc chamber. That is, the spacing or clearance c between the conducting blade and the horn fibre walls preferably is approximately the same at opposite sides and at the upper and lower edges of the blade.

I have found that the clearance c can be expressed in inches as approximately

$$\frac{1.14 \text{ KV}}{P}$$

where KV is the single-phase circuit voltage in kilovolts and P is the gas supply pressure in pounds per square inch. It shall be understood, of course, that we are dealing here with high voltage power breakers, and for this reason the above formula is not intended to apply in the case of three-phase voltages of less than 22 kv., or to gas supply pressures of less than 50 pounds per square inch. Also it is assumed that the blade contact, which is the arcing contact, has sufficient copper cross section to carry without overheating the main line current. Blade contacts of the usual design, approximately 1/2 inch in width, have been found suitable for this purpose in power breakers of the type under consideration.

The spacing or clearance c obtained by the above formula is an approximate optimum for the single-phase circuit voltage used, and for best results the solid insulating walls should not be appreciably closer at any point to the blade-conducting portions in the region of the arc gap.

For example, if the single-phase voltage is 44 kv. and an air supply pressure of 100 pounds per square inch is used, the preferred clearance in inches is indicated as follows:

$$c = \frac{1.14 \text{ KV}}{P} = \frac{1.14 \times 44}{100} = .5016''$$

or approximately 1/2 inch; this being the same in the case where the voltage is 88 kv. and the air supply pressure 200 pounds per square inch, since at a higher gas pressure (the voltage being the same) the maximum contact separation is less at interruption.

A rough approximation for the minimum clearance is simply

$$\frac{\text{KV}}{P}$$

and it is within the scope of my invention to

use this value as a bare minimum. It will be apparent, however, in the case of larger clearances, that the economics of circuit breaker design will be controlling. In other words, there is no particular reason for greatly exceeding the minimum clearance required since the breaker would then be larger and more expensive. However, a fairly practicable and efficient range for values of c is from

$$\frac{KV}{P} \text{ to } \frac{1.5KV}{P}$$

it being understood, of course, that the preferred value is approximately

$$\frac{1.14KV}{P}$$

as set forth.

In order to increase the "creepage distance" along the side walls of the arc chamber, a plurality of transversely extending grooves 19 can be provided in the wall surfaces as indicated by Figs. 1 and 2. By increasing the creepage distance between the separated electrodes at the time of interruption, the likelihood of flashover along the interconnecting insulating surfaces is correspondingly diminished.

It should be understood that my invention is not limited to specific details of construction and arrangement thereof herein illustrated, and that changes and modifications may occur to one skilled in the art without departing from the spirit 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 gas blast type for high voltage power circuits comprising relatively movable contacts, insulating structure defining an arc chamber in which said contacts separate to form an arc gap, the walls of said arc chamber along the path of contact movement being appreciably spaced at both lateral sides and at both the upper and lower sides an appreciable and approximately equal distance from the separable contact structure, and means for directing a blast of interrupting gas transversely through said chamber and the arc gap formed therein.

2. An electric circuit breaker of the gas blast type for high voltage power circuits comprising a relatively fixed contact and a movable rod contact, insulating structure defining an arc chamber in which said rod contact is longitudinally movable to form an arc gap, the walls of said arc chamber along the path of movement of said rod contact being appreciably spaced at both lateral sides and at both the upper and lower sides an appreciable and approximately equal distance from the conducting contact material of said rod contact so that the electrostatic stress at said arc gap is less likely to cause voltage breakdown of the gap dielectric after current interruption, and means for directing a blast of interrupting gas transversely through said chamber and said arc gap.

3. An electric circuit breaker of the gas blast type for high voltage power circuits comprising a relatively fixed contact and a movable contact, insulating arc chute structure defining an elongated arc chamber in which said contacts separate to form an arc gap, a gas blast supply conduit connected to one side of said chamber and arc extinguishing structure disposed at the opposite side thereof, the insulating walls of said arc chamber along the path of movement of said

movable contact being appreciably spaced at both lateral sides and at both the upper and lower sides an appreciable and approximately equal distance from the conducting material of said movable contact so that a high degree of electrostatic stress tending to cause voltage breakdown at said arc gap is substantially precluded when the power current is interrupted at a current zero by a blast of gas traversing said arc gap.

4. An electric circuit breaker of the gas blast type for high voltage power circuits comprising relatively movable contacts, insulating structure defining an arc chamber in which said contacts separate to form an arc gap, the cross sectional area of said chamber being generally rectangular in shape and large as compared with the cross sectional area of the movable contact structure, the insulating walls of said arc chamber being appreciably spaced at both lateral sides and at both the upper and lower sides an appreciable and approximately equal distance from said movable contact structure, said chamber at one side being connected to a gas blast supply conduit and at the opposite side having a restricted gas passage leading to arc extinguishing structure, the aforesaid geometrical relationship of said arc chamber to said movable contact structure providing a comparatively even distribution of electrostatic stress whereby voltage breakdown of the gap dielectric after current interruption at a current zero is minimized.

5. An electric circuit breaker of the gas blast type for high voltage power circuits comprising relatively movable contacts, an arc chamber having insulating side walls extending along the path of contact movement, said contacts separable in said chamber to form an arc gap longitudinally thereof, the walls of said arc chamber substantially along the path of contact movement being spaced at both lateral sides and at both the upper and lower sides an approximately equal distance from the separable contact structure, said distance corresponding in inches to

$$1.14 \frac{KV}{P}$$

where KV is the single-phase circuit voltage in kilovolts and P is the gas supply pressure in pounds per square inch, and means for directing a blast of interrupting gas transversely through said chamber and the arc gap formed therein.

6. An electric circuit breaker of the air blast type for high voltage power circuits comprising relatively movable contacts, an arc chamber having insulating side walls substantially surrounding the arc gap formed by contact movement, said contacts separable in said chamber to form the arc gap longitudinally thereof, the walls of said arc chamber along the path of contact movement being spaced at both lateral sides and at both the upper and lower sides an approximately equal distance from the conducting portions of the separable contact structure, said distance corresponding in inches at least to

$$\frac{KV}{P}$$

where KV is the single-phase circuit voltage in kilovolts and P is the gas supply pressure in pounds per square inch, and means for directing a blast of interrupting gas transversely through said chamber and the arc gap formed therein.

7. An electric circuit breaker of the air blast

type for high voltage power circuits comprising relatively fixed and movable contacts, the movable contact being of blade-like form having a substantially rectangular cross-sectional area, an elongated arc chamber having insulating side walls, said contacts separable in said chamber to form an arc gap longitudinally thereof, the walls of said arc chamber along the path of movement of the blade-like contact being spaced at both lateral sides and at both the upper and lower sides an approximately equal distance from the conducting portions of the blade-like contact so that said arc gap is spaced an appreciable distance from the solid insulating chamber walls, said distance corresponding in inches to approximately

$$1.14 \frac{KV}{P}$$

where KV is the single-phase circuit voltage in kilovolts and P is the gas supply pressure in pounds per square inch, and means for directing a blast of interrupting gas transversely through said chamber and the arc gap formed therein.

8. An electric circuit breaker of the gas blast type for high voltage power circuits comprising relatively movable contacts separable to form an arc gap, an arc chamber having insulating side walls substantially surrounding the arc gap so formed, the walls of said arc chamber along the path of contact movement being spaced at both lateral sides and at both the upper and lower sides an approximately equal clearance from the separable contact structure, said clearance in inches being within the limits of from

$$\frac{KV}{P} \text{ to } \frac{1.5KV}{P}$$

where KV is the single-phase circuit voltage in kilovolts and P is the gas supply pressure in pounds per square inch, and means for directing a blast of interrupting gas transversely through said chamber and the arc gap formed therein.

9. An electric circuit breaker of the air blast type for high voltage power circuits comprising relatively fixed and movable contacts, the movable contact being of blade-like form having a substantially rectangular cross-sectional area, an elongated arc chamber having insulating side walls, said contacts separable in said chamber to form an arc gap longitudinally thereof, the walls of said arc chamber along the path of movement of the blade-like contact being spaced at both lateral sides an approximately equal distance from the conducting portions of the blade-like contact so that said arc gap is spaced an appreciable distance from the solid insulating chamber side walls, said distance corresponding in inches to approximately

$$1.14 \frac{KV}{P}$$

where KV is the single-phase circuit voltage in kilovolts and P is the gas supply pressure in pounds per square inch, and means for directing a blast of interrupting gas transversely through said chamber and the arc gap formed therein.

10. An electric circuit breaker of the gas blast type for high voltage power circuits comprising relatively movable contacts separable to form an arc gap, an arc chamber having insulating side walls substantially surrounding the arc gap so

formed, the walls of said arc chamber along the path of contact movement being spaced at both lateral sides an approximately equal clearance from the separable contact structure, said clearance in inches being within the limits of from

$$\frac{KV}{P} \text{ to } \frac{1.5KV}{P}$$

where KV is the single-phase circuit voltage in kilovolts and P is the gas supply pressure in pounds per square inch, and means for directing a blast of interrupting gas transversely through said chamber and the arc gap formed therein.

11. An electric circuit breaker of the air blast type for high voltage power circuits comprising relatively movable contacts, an arc chamber having insulating side walls substantially surrounding the arc gap formed by contact movement, said contacts separable in said chamber to form the arc gap longitudinally thereof, the walls of said arc chamber along the path of contact movement being spaced at both lateral sides an approximately equal distance from the conducting portions of the separable contact structure, said distance corresponding in inches at least to

$$\frac{KV}{P}$$

where KV is the single-phase circuit voltage in kilovolts and P is the gas supply pressure in pounds per square inch, and means for directing a blast of interrupting gas transversely through said chamber and the arc gap formed therein.

12. An electric circuit breaker of the gas blast type for high voltage power circuits comprising a relatively fixed contact and a movable rod contact, insulating structure defining an arc chamber in which said rod contact is longitudinally movable to form an arc gap, the side walls of said arc chamber along the path of movement of said rod contact being appreciably spaced at both lateral sides an appreciable and approximately equal distance from the conducting contact material of said rod contact so that the electrostatic stress at said arc gap is less likely to cause voltage breakdown of the gap dielectric after current interruption, and means for directing a blast of interrupting gas transversely through said chamber and said arc gap.

13. An electric circuit breaker of the gas blast type for high voltage power circuits comprising a relatively fixed contact and a movable contact, insulating arc chute structure defining an arc chamber in which said contacts separate to form an arc gap, a gas blast supply conduit connected to one side of said chamber and arc extinguishing structure disposed at the opposite side thereof, the insulating side walls of said arc chamber along the path of movement of said movable contact being appreciably spaced at both lateral sides an appreciable and approximately equal distance from the conducting material of said movable contact and the insulating wall structure at both the upper and lower sides of said chamber also being spaced an appreciable distance from said contact material so that a high degree of electrostatic stress tending to cause voltage breakdown at said arc gap is substantially precluded when the power current is interrupted at a current zero by a blast of gas traversing said arc gap.

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