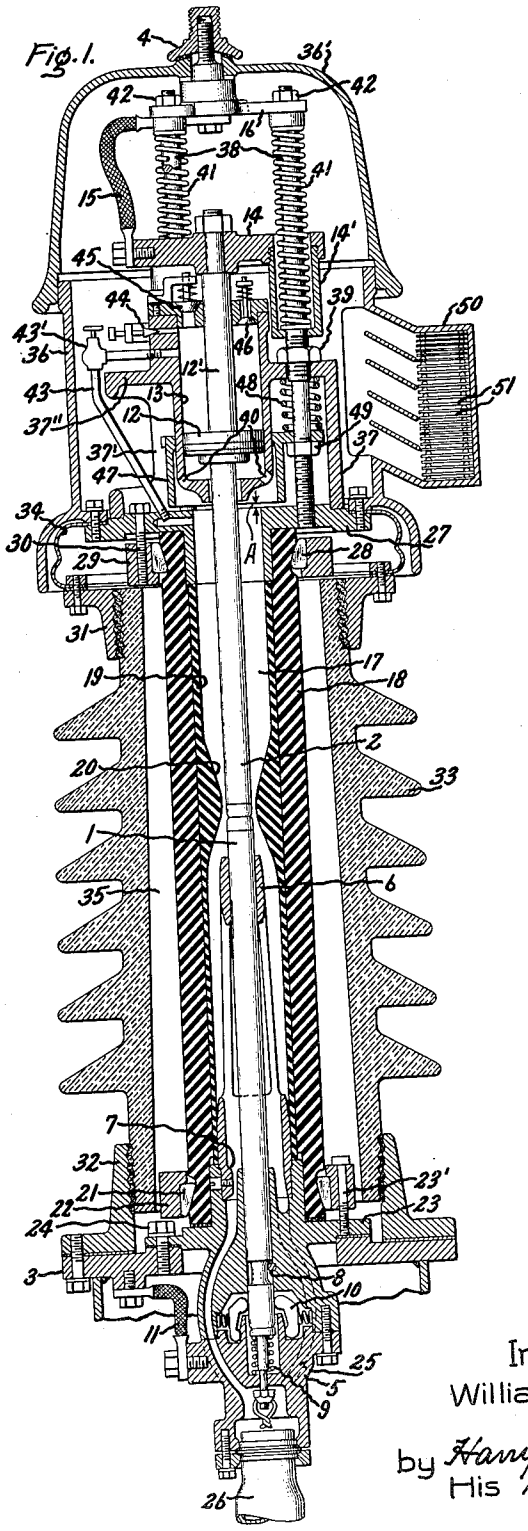
Dec. 22, 1942. W. K. RANKIN 2,306,186

HIGH VOLTAGE ELECTRIC CIRCUIT BREAKER

Filed Jan. 27, 1941 2 Sheets-Sheet 1

Fig. 1.



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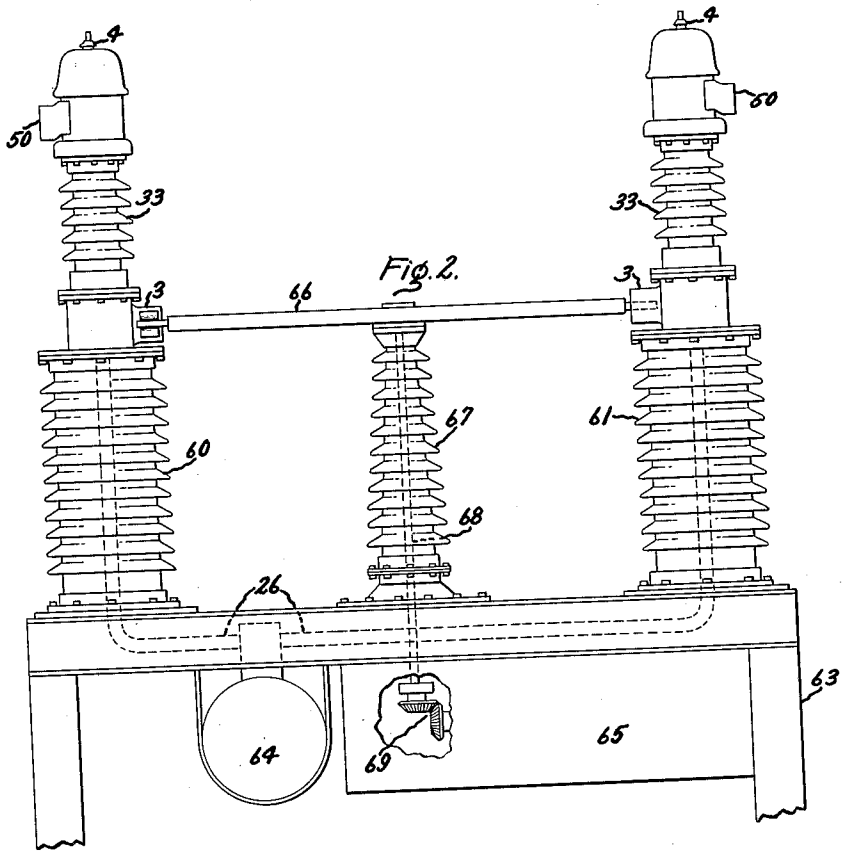


Fig. 2.

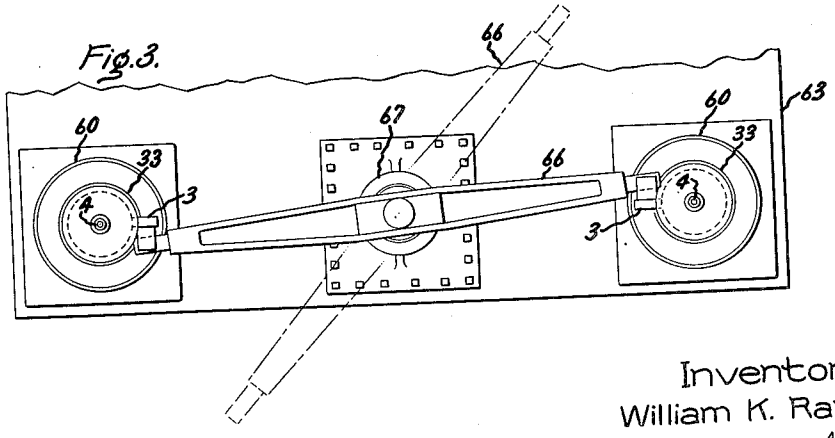


Fig. 3.

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Patented Dec. 22, 1942

2,306,186

UNITED STATES PATENT OFFICE

2,306,186

HIGH VOLTAGE ELECTRIC CIRCUIT BREAKER

William K. Rankin, Lansdowne, Pa., assignor to General Electric Company, a corporation of New York

Application January 27, 1941, Serial No. 376,215

8 Claims. (Cl. 200—148)

My invention relates to high voltage electric circuit breakers, more particularly to circuit breakers of the gas blast type having separable contacts between which a blast of gas is directed for extinguishing arcing, and has for its principal object the provision of an improved gas blast circuit breaker operable at high transmission line voltages and capable of efficiently interrupting and clearing high voltage power circuits.

The interruption of a high voltage power circuit, such as for example a 138 kv. circuit, by means of a gas blast involves a number of difficult problems due to the limited dielectric strength of gases (such as air) most commonly used. Heretofore, oil circuit breakers have been almost exclusively used for such interrupting duty since the dielectric strength of oil is many times that of air. Accordingly, when the arc is extinguished at a current zero by the oil circuit breaker, the intervening oil dielectric is much better able to withstand the returning recovery voltage than air. Reestablishment of the arc therefore does not occur and the circuit remains open. Air on the other hand may be so stressed by the recovery voltage across the interrupting gap that breakdown occurs. The power arc is thereby reignited and failure of the breaker results.

In accordance with my invention, the high voltage range of a gas or air blast circuit breaker is greatly increased by utilizing the increased dielectric strength of gas under pressure, during interruption, so as to minimize the danger of restriking of the arc within the interrupting chamber, without however impairing the arc-extinguishing action of the blast.

It is known that the dielectric strength of a gas increases according to pressure increase; also that, in a nozzle, a back pressure in excess of 50% of the applied pressure may be permitted with no appreciable decrease in the velocity of the gas through the nozzle. My invention in combination makes effective use of these phenomena by separating interrupting contacts to draw an arc in a chamber in which a relatively high pressure exists, or is applied co-incident with contact separation. This arc chamber pressure does not impede the velocity or impair the effectiveness of the interrupting gas blast. An interrupter constructed in accordance with my invention is found to have the same ability to interrupt current as one using a similar but freely vented nozzle, and in addition is operable at much higher voltages.

In practicing my invention, the interrupting chamber communicating with the source of blast pressure is provided with a venting or exhaust opening having a suitable cross-sectional area that is related to the interrupting chamber and blast pressure so as to insure effective blast velocity for arc interruption while maintaining the interrupting chamber atmosphere surrounding the interrupting gap at a substantially predetermined related pressure. In order to provide for unusual or variable operating conditions, means are also provided for further increasing the aforesaid cross-sectional area of the exhaust blast opening in accordance with the pressure in the interrupting chamber.

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, sectional view of a high voltage gas blast circuit breaker embodying the present invention in the closed circuit position thereof, Fig. 2 is an elevational view of a single phase double-break outdoor circuit breaker of the character shown by Fig. 1 with disconnecting means intermediate the dual interrupting units, and Fig. 3 is a plan view of Fig. 2 illustrating the operation of the disconnecting means.

Referring to Fig. 1, the high voltage circuit breaker comprises essentially separable contacts 1 and 2 which are connected respectively to the breaker terminals 3 and 4. The rod contact 1 is relatively fixed and is held in position by conducting structure 5 and a guide bushing 6 suitably connected to the conducting structure as indicated at 7. The contact 1 is mounted within and centrally of the conducting structure 5 for limited movement, or "wipe," as indicated at 8. In the position shown, the contact 1 is held in contact engagement by means of a biasing spring 9 mounted within the conducting structure 5. Sliding contact structure 10 electrically connects the rod contact 1 to the structure 5, which is in turn electrically connected by the conductor 11 to the breaker terminal 3.

The coacting or movable rod contact 2 is connected to an operating piston 12 operable within a cylinder 13 for moving the contact 2 into and out of circuit making engagement with the contact 1. The contact 2 is electrically connected to the other breaker terminal at 4 through a conducting spring guide and bearing plate 14 car-

ried by the contact extension 12' (hereinafter described), a flexible conductor 15 and a fixed conducting spider 16.

The contacts 1 and 2 are separable within an interrupting chamber 17 which, in the present instance, is elongated and formed by an insulating tube 18 composed of mechanically strong insulating material, such as hard fibre. The insulating tube 18, which is capable of withstanding high internal bursting pressures, is provided with an insulating lining 19 of suitable arc resisting insulating material. The insulating lining 19 forms at 20 substantially at the point of separation of the contacts 1 and 2 a restricted nozzle-like section in the interrupting chamber. Accordingly, when gas under pressure is admitted to the lower end of the interrupting chamber, the arc gap formed at the constriction 20 when the gas pressure has elevated the piston 12 causes an arc extinguishing blast longitudinally of the arc as it is drawn into the upper part of the interrupting chamber 17.

The mechanical stresses incident to the application of the gas blast (which in the case of air may be introduced at approximately 350 lbs. per sq. in.) require that the interrupting chamber and its insulating structure be physically rugged as well as electrically efficient at high voltages. To this end, the insulating tube 18 is secured at its lower end, as by a ring-shaped clamping wedge 21 and clamping flange 22, to a base plate 23 (as indicated at 23') that is in turn bolted at 24 to the lower terminal structure 3. The base plate 23 is an integral part of the depending contact supporting structure 5 through which a plurality of parallel connected gas passages 25 interconnect the lower end of the arc chamber and the gas supply conduit 26. The upper end of the insulating tube 18 is similarly secured to a top supporting plate 27 by a clamping ring 28 and flange 29 that is bolted at 30 to the top plate.

Between a pair of supporting flanges 31 and 32 secured respectively to the top plate 27 and the lower terminal base plate 3 is mounted a high voltage insulator shell 33 surrounding and spaced with respect to the tube 18. The insulating shell 33 is of the high voltage outdoor type composed of ceramic material, such as porcelain, and is resiliently connected to the upper plate through a flexible corrugated coupling 34 as illustrated for preventing transmission of excessive shock to the porcelain insulator. The annular space 35 between the tube 18 and the insulator 33 is preferably filled with a non-inflammable insulating liquid of high dielectric strength, such as for example a liquid chlorinated hydrocarbon described and claimed in Clark Patent No. 1,931,-455, granted October 17, 1933, for "Dielectric materials for electrical devices."

The top plate 27 forms a base for supporting the piston cylinder 13 and its associated apparatus, the blast exhaust controlling means and the housing 36 therefor. More specifically, the piston cylinder 13 is secured in position through interconnecting flange 37'' by means of its integral concentric supporting cylinder 37 which seats in an annular recess in the upper face of the supporting plate 27 and is clamped therein by nuts 39 threaded on three evenly spaced studs 38 screwed into the supporting plate 27. Large ports 37' are provided in the supporting cylinder side wall. The cylinder 13 is therefore rigidly secured to the supporting plate 27 and the lower end thereof, which is provided with ports 40 directly communicating with the interrupting chamber 17, is arranged to admit gas under pressure to the lower side of the piston 12, which is spring biased toward closed circuit position.

The piston biasing means comprises in the present instance the movable spring bearing plate 14 on the end of the piston rod (and contact) extension 12' between which and the upper fixed spring bearing plate (or spider) 16 are mounted biasing springs 41. The springs 41 are guided on the through bolts 38 which are secured at their upper ends at 42 to the fixed plate 16. The plate 16 in turn serves as an anchorage for the upper part of the housing 36 which constitutes a dome-shaped cover member 36'. For the purpose of providing low gradient spring action, the spring bearing plates 14 are provided with socket-like extensions 14' in which the springs 41 are seated and which are guided for reciprocal vertical movement by the through bolts 38. Accordingly, when the piston 12 is raised by the blast pressure, the spring bearing plate 14 is correspondingly raised to compress the springs 41, thereby storing energy for closing the contact 2 upon cut-off of blast pressure.

For the purpose of controlling the operation of the contact piston 12 so that there is no appreciable tendency to rebound near the end of the opening stroke, and also so that the breaker cam, if desired, be reclosed at the proper speed, the cylinder 13 is provided with valve means for controlling pressure within the cylinder. A by-pass connection 43 between the interrupting chamber 17 and the upper part of the cylinder tends to equalize pressure on both sides of the piston near the end of the opening stroke for slowing up the speed thereof. This eliminates shock and excessive stresses at the end of the opening stroke. This buffer action can be nicely regulated and adjusted by a valve 43' connected in the by-pass connection and by an adjustable bleed valve indicated at 44 connecting with the upper cylinder space.

In case excessive back pressure tends to build up in the upper cylinder space causing rebound of the piston 12 with possible reestablishment of arcing between the contacts, a spring loaded excess pressure valve 45 controls a port in the cylinder wall for relieving the cylinder pressure when it reaches a predetermined value. Accordingly, the piston 12 is not only provided with buffer means for the opening stroke, but is prevented from rebounding due to excessive buffer action.

In certain cases, it is desirable to reclose the breaker as soon as possible after it has been opened to clear a fault condition. For such operation, it is necessary that the piston 12 be permitted to move under influence of its biasing springs 41 downward to closed circuit position immediately after the opening operation without appreciable retarding effect. For this purpose a non-return valve indicated at 46 controls a port in the upper cylinder wall for opening under atmospheric pressure when the piston descends so as to prevent creation of a partial vacuum in the upper cylinder space with resultant retarding effect on the piston. This valve of course remains closed when the piston is moving upward.

Let it now be assumed that the breaker is closed as illustrated and that an opening operation has been initiated by the opening of a suitable control valve (not shown) for admitting gas under pressure into the interrupting chamber by way of the supply conduit 26. As the gas rushes

upward through the chamber, it is throttled at the constriction 20 so that it flows at high velocity past this point and enters the lower part of the cylinder 13 to act directly on the contact piston 12. It will be noted that as the piston 12 is raised to separate the contacts 1 and 2, the gas blast is already passing through the nozzle portion 20 so that immediately upon formation of the arc it is acted upon by an intensive cooling and interrupting blast at the nozzle. This extinguishing action is generally sufficient to interrupt the arc at a current zero before it has been drawn to the maximum length determined by the piston stroke in the chamber 17.

The contact arrangement with relation to the interrupting chamber and blast pressure also aids current interruption. That is, the movable contact moves away from the nozzle restriction in the direction of the blast to draw the arc into the pressure exhaust chamber where, from its inception, it is effectively surrounded for cooling and positioned axially by an insulating hose-like blast of pressure gas. The arc is therefore drawn straight and at the end of the stroke has a predetermined length as compared with a looped or bowed arc.

However, the interruption of the arc at a current zero by the intense gas blast at the interrupting nozzle does not necessarily complete the circuit opening operation since, as previously pointed out, the returning recovery voltage across the breaker terminals may break down the air gap between the contacts 1 and 2 and so cause restriking of the arc. In order to prevent this, the interrupting chamber 17 at the exhaust side of the interrupting nozzle 20 is so vented that the gas in this part of the chamber is partially entrapped to set up an effective back pressure level sufficient appreciably to increase the dielectric strength of the gas during the separation of the contacts. It will therefore be noted that it is necessary to initiate and establish a back pressure in the exhaust chamber beyond the nozzle throat to cause separation of the contacts, so that the arc, from its inception, is encompassed by gas appreciably above atmospheric pressure. In the specific arrangement described, the initial or source blast pressure is approximately 350 lbs. per sq. in. and the average controlled back pressure is calculated for approximately 120# sq. in. at which the dielectric strength of the air may be several times the value it would be with free venting. Using 350# blast pressure it will be appreciated that even a back pressure as high as 180 lbs. per sq. in. at the exhaust end of the interrupting nozzle 20 has no retarding effect on the interrupting blast velocity since the back pressure at an orifice can be approximately 53% of the source pressure without causing decrease of the rate of discharge through the orifice. Also, such control of the back pressure avoids wider and disruptive stress differentials within the device during high current interruptions.

The blast exhaust opening is formed by an annular valve-like control member 47 guided in sleeve-like manner for limited vertical, rectilinear movement on the cylinder 13. The member is biased toward its normal lower position by springs 48 mounted on the through bolts 38 between the cylinder interconnecting flange 37'' and offset flanges or legs on the control member 47. The member 47 is held in spaced relation to the supporting plate 27 by fixed lock nuts 49 on the through bolts 38 so as to form an annular venting opening, the cross-sectional area of which is determined by the spacing A and the circumference of the member 47. The lock nuts 49 also provide means for adjusting the position of the member 47 for regulating to a fine degree the venting area.

In the specific interrupter herein described, this pre-set venting area is related both to the opening and closing operations. It is small enough to throttle the interrupting blast so that the arc is drawn and extinguished (usually at an early current zero) in a region of high pressure air or gas; at the same time being large enough to permit decisive reclosure of the piston contact, under the bias of its return springs, immediately following the blast cut-off. In the present instance optimum results were attained with an initial vent area of 2.79 sq. in. for an interrupting chamber cross-sectional area of 6.75 sq. in., a cross-sectional nozzle area of 1.75 sq. in. and nozzle exhaust and source pressures of 120 lbs. per sq. in. and 350 lbs. per sq. in respectively The ratio of the vent or exhaust area to the nozzle area is therefore approximately 1.6. When the back pressure is restricted within the proper zone, which may vary in accordance with the character of the extinguishing gas employed, the breaker is capable of successfully interrupting and clearing the circuit at much higher voltages than previously possible.

For example, from tests made on comparable experimental single interrupting units the following comparisons were observed. The nozzle employing the restricted exhaust is capable of interrupting at least 21% more current at 44 kv. and 124% more current at 66 kv. than an equivalent nozzle exhausting to the open air. At 88 kv. the nozzle exhausting to the open air was incapable of interrupting any current at all, while the restricted exhaust nozzle interrupted 2280 amperes successfully. This, together with other test data, has permitted the successful manufacture, for commercial use, of the 138 kv. circuit breaker herein described which is rated at 1,500,000 kva. interrupting capacity.

The venting control arrangement is also provided with means for increasing the venting area in case unusual and abnormally high pressures, such as in excess of 150 lbs. per sq. in., are generated within the interrupting chamber, for, as previously described, the member 47 can move upwardly on the guide bolts 38 against the bias of springs 48, although in usual operation the springs 48 maintain the venting area substantially fixed and uniform. Hence, the use of a biased valve is not essential to practice my invention, for fixed vent openings may be used to effect the proper blast and exhaust pressure relationship after the latter has been ascertained for a given breaker.

The hot exhaust gases that flow into the housing 36 are finally vented to atmosphere, after passing through ports 37', at the muffler 50 which is provided with suitable cooling plates or the like 51 for preventing or minimizing flame emission from the breaker.

It is within the scope of my invention to employ other methods than that specifically described for providing a suitable pressure level in the exhaust chamber where the arc is interrupted. For example, two different pressures may be admitted substantially simultaneously to the chambers at opposite sides of the nozzle or break-point respectively in accordance with the pressure relationship set forth. Conveniently,

the exhaust chamber in such an arrangement might be connected to the main pressure source through a reducing valve.

The circuit breaker herein described automatically recloses after a complete opening operation, i. e., as defined by closing of the main blast control valve. It is therefore necessary that other means in series with the breaker be provided for disconnecting the breaker with respect to the power circuit after circuit interruption and prior to reclosing of the breaker. Figs. 2 and 3 show one phase of a triple-pole outdoor type circuit breaker of the character herein described, each interrupting unit of which corresponds to that illustrated by Fig. 1. The two units are mounted on high voltage shell-like insulating supports **60** and **61** respectively, which are in turn mounted on a supporting frame **63** composed of structural steel work. The frame **63** also supports in depending relation therefrom a gas supply tank **64** which is adapted to supply both breaker units through the conduits at **26**, and a suitable operating mechanism **65** for the disconnecting means hereinafter described.

The lower terminals **3** of the breaker units are provided with suitable contact engaging surfaces for coacting with a movable disconnecting switch blade **66** that is mounted for rotatable movement with respect to the terminals on an insulating support **67** likewise mounted on the frame **63**. The disconnecting switch blade **66** when rotated approximately 45° in clockwise direction as viewed in Fig. 3 disconnects both breaker units at the terminals **3** so that the power circuit is disconnected. When the blade is in connecting position bridging the terminals **3**, and the breaker units are closed, the power circuit is complete between the upper breaker terminals **4**, the current path from the upper terminal **4** of the left-hand unit including the corresponding breaker unit, the bridging disconnecting switch blade **66** and the right-hand unit and its upper terminal **4**.

Any suitable means may be provided for operating the blade **66**, and by way of example an operating rod **68** secured to the blade and journalled for rotative movement within the insulating support **67** is operatively connected to suitable actuating means by bevel gearing at **69**. The means for properly operating the disconnecting switch with reference to the breaker operation forms no part of the present invention and a detailed description thereof is unnecessary for the purpose of understanding and practicing this invention. One such arrangement is described and claimed in a copending application Serial No. 367,789, filed November 29, 1940, by Carl Thumim and Alexander C. Boisseau for "Circuit breaker operating system."

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. A high voltage electric circuit breaker of the gas blast type comprising relatively movable contacts, an elongated arc extinguishing chamber having a restricted cross-sectional area at which said contacts are separable to form an arc gap, a source of gas pressure for supplying to said chamber at one side of said restriction an arc extinguishing gas under pressure so that the arc in said restriction is traversed by a gas blast, means defining at the opposite side of said restriction a blast exhaust opening having a predetermined minimum venting area so related to the pressure of the gas supplied to said chamber that the gas pressure within said chamber is sufficiently high to prevent breakdown of said gap after arc interruption without affecting the arc extinguishing action of the blast within said chamber, the ratio of the venting area of said exhaust opening to the area of the aforesaid restricted part of the arc chamber being in the neighborhood of 1.6.

2. A high voltage electric circuit breaker of the gas blast type comprising relatively movable contacts one of which is biased toward closed circuit position, an operating piston connected to said biased contact, an arc extinguishing chamber having a restricted cross-sectional area in which said contacts are separable to form an arc gap, a source of gas pressure for supplying to said operating piston and to said chamber at one side of said restriction an arc extinguishing gas under pressure, said piston and biased contact being at the exhaust side of said restriction, means defining at said exhaust side of said restriction a blast exhaust opening that has a predetermined minimum cross-sectional area so that the gas pressure within said chamber is maintained sufficiently high to prevent breakdown of said gap after arc interruption and the gas blast in said chamber is of sufficient velocity to insure interruption of the arc, and valve means for further increasing the cross-sectional area of said exhaust opening when the pressure in said extinguishing chamber exceeds a predetermined amount.

3. A high voltage electric circuit breaker of the gas blast type comprising an elongated arc interrupting chamber, said chamber having a constricted nozzle-like portion at an intermediate part of its length, a relatively fixed contact mounted in one end of said chamber and extending to said nozzle portion, a coacting movable rod contact arranged to engage said fixed contact at said nozzle portion, an operating piston connected to said movable contact, means for admitting gas under pressure to the fixed contact end of said chamber for producing an extinguishing blast at said nozzle portion and for actuating said piston, and venting control means for the exhaust end of said chamber arranged to define a blast exhaust opening of predetermined cross-sectional area that is an optimum for maintaining the gas at the exhaust end of said chamber at sufficient dielectric strength coexistent with effective interrupting blast velocity at said nozzle portion.

4. A high voltage gas blast circuit breaker comprising an elongated insulating interrupting chamber, fixed and movable contacts separable to form an arc gap extending along the longitudinal axis of said chamber, said chamber having a restriction in respect to its cross-sectional area disposed intermediate the ends of said chamber at which contact separation takes place, means for directing gas under pressure to said chamber at one end thereof for establishing an interrupting blast at said restriction, means for so confining the exhaust blast in said chamber at the opposite end thereof that the exhaust chamber pressure beyond said restriction is at a sufficient level to increase appreciably the dielectric strength of the gas but is not high enough to reduce the interrupting blast velocity at said re-

striction, said fixed contact being disposed in said chamber at the pressure entrance end thereof and said movable contact being disposed at the exhaust end of said chamber, and a piston connected to said movable contact and operable by gas pressure for drawing the power arc at said movable contact axially into said exhaust chamber in the direction of the gas blast so that said arc is enveloped by said gas blast.

5. A high voltage gas blast circuit breaker comprising an insulating interrupting chamber, contacts separable to form an arc gap in said chamber, said chamber having a constriction through which a gas under pressure is directed to extinguish arcing at said gap, said chamber at the exhaust side of said constriction being of sufficient size substantially to enclose said arc gap, and means for so restraining flow of blast gas from said exhaust chamber that a pressure level is built up in said exhaust chamber sufficient to increase appreciably the dielectric strength of said gas by the time said contacts separate for preventing restriking of the arc after interruption at a current zero, said pressure level being related to the gas pressure at the entrance side of said constriction so that the effectiveness of the interrupting gas blast through said constriction is not impaired.

6. A high voltage electric circuit breaker of the gas blast type comprising relatively fixed and movable rod contacts disposed in vertical alignment, a tubular sleeve-like arc extinguishing chamber in which said contacts are separable to form an arc gap, the point of contact separation being at a restricted section of said chamber, a source of gas pressure for supplying an arc extinguishing gas to said chamber, a substantially circular port defining a radial exhaust opening at the upper end of said chamber of such predetermined cross-sectional area with respect to the cross-sectional area of said restricted section that the gas pressure within said chamber is maintained sufficiently high during the gas blast to prevent breakdown of said gap after arc interruption, spring-biased means for further increasing the cross-sectional area of said exhaust opening in accordance with predetermined increase of pressure within said chamber, and a piston disposed at the upper part of said chamber connected to the movable contact for causing separation of said contacts in response to the admission of gas under pressure to said chamber, said piston and movable contact being mounted for reciprocal movement concentrically with repect to said radial exhaust opening.

7. A high voltage electric circuit breaker of the gas blast type comprising relatively fixed and movable rod contacts disposed in vertical alignment, an insulating tube forming a sleeve-like arc extinguishing chamber in which said contacts are separable, the point of contact separation being at a restricted section of said chamber so as to form the initial arc gap in said section, a source of gas pressure for supplying an arc extinguishing gas to the lower part of said chamber, a substantially annular member defining an exhaust opening at the upper end of said chamber, said opening having a minimum predetermined cross-sectional area with respect to the cross-sectional area of said restricted section so arranged that the gas pressure within said chamber is maintained sufficiently high during the gas blast to prevent breakdown of said gap after arc interruption, spring means coacting with said annular member opposing the chamber gas pressure for permitting further increase in the cross-sectional area of said exhaust opening in accordance with predetermined increase of pressure within said chamber, and a piston disposed at the upper part of said chamber connected to the movable contact for causing separation of said contacts in response to the admission of gas under pressure to said chamber, said piston and movable contact being mounted for reciprocal movement within said spring-biased member.

8. A high voltage electric circuit breaker of the gas blast type comprising relatively fixed and movable rod contacts disposed in vertical alignment, an insulating tube forming a sleeve-like arc extinguishing chamber in which said contacts are separable to form an arc gap, the point of contact separation being at a restricted section of said chamber, a high voltage insulating shell surrounding said tube, a source of gas pressure for supplying an arc extinguishing gas to the lower end of said tube, a member normally spaced with respect to said tube defining therewith an exhaust opening at the upper end of said chamber having a predetermined minimum cross-sectional area, said area being about 1.6 times the cross-sectional area of said restricted section whereby the gas pressure within said chamber is maintained sufficiently high during the gas blast to prevent breakdown of said gap after arc interruption, means resiliently biasing said member toward said predetermined minimum spacing so that the cross-sectional area of said exhaust opening can be further increased in accordance with predetermined increase of pressure within said chamber, a piston disposed at the upper part of said chamber connected to the movable contact for causing separation of said contacts in response to the admission of gas under pressure to said chamber, a cylinder for said piston having valve controlled means for regulating the speed of said piston in both directions, a housing for said cylinder and member mounted at the upper end of said insulating shell arranged to receive the arc chamber exhaust gases, and cooling structure in said housing through which said gases are directed to atmosphere.

WILLIAM K. RANKIN.