

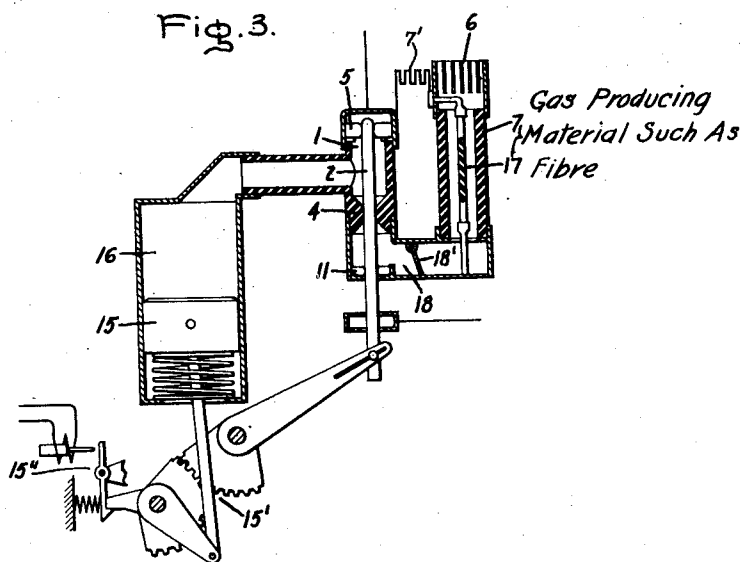
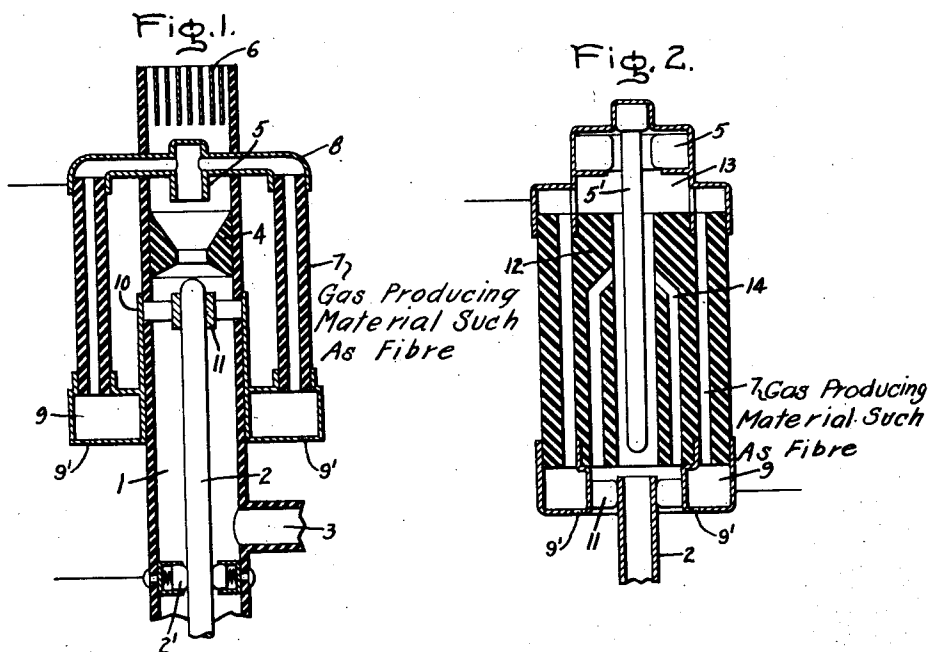
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ALTERNATING CURRENT CIRCUIT INTERRUPTER

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ALTERNATING CURRENT CIRCUIT  
INTERRUPTERVitaly Grosse, Berlin-Lichterfelde, Germany, as-  
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My invention relates to alternating current circuit interrupters, and particularly to circuit interrupters for high voltage circuits that are characterized by high rates of increase of recovery voltage across the interrupting gap formed upon opening of the circuit.

Alternating current circuit breakers operating at high voltages function to interrupt the arc practically at the passage of the current through zero. Upon interruption of the current, the voltage impressed across the contacts at the interrupting gap of the circuit breaker swings rapidly to the instantaneous value of the voltage of the main circuit. The natural frequency of this swing is determined by the circuit capacitance which is connected in parallel with the terminals of the breaker, and by the circuit inductance which tends to retard the discharge of the aforesaid capacitance through the voltage source. In the case of undamped oscillation, the voltage across the terminals of the breaker can assume momentary values as great as twice the maximum value of the line voltage. For this reason, re-establishing of the arc due to break-down of the interrupting gap may readily occur after momentary interruption, resulting in lengthening of the duration of arcing or even failure of the breaker.

By effective damping of the circuit, the swing or oscillation beyond the value of the main line voltage can be substantially prevented. For example, for the purpose of damping, an effective resistance can be connected in parallel with the terminals of the breaker so that the maximum value of the recovery voltage is greatly reduced, as is also its rate of increase. Accordingly, the interrupting capacity of the breaker can be substantially increased by means of a parallel resistance used in the above manner. Also the severity of the interrupting duty on the breaker can be decreased. It has been proposed to connect metallic resistances across the interrupting gap in the manner above described, but this method involves certain complications including the necessity of interrupting the residual current after the resistance has been inserted in circuit.

In accordance with my invention, the circuit is damped at least in part by means of a momentarily hot conductor characterized by a negative temperature coefficient connected in parallel with the interrupting gap. The character of the hot conductor circuit is such that when the current passes through zero the recovery voltage is damped and retarded coincident with momentary arc interruption by the extinguishing agency. After arc interruption the resistance of the hot

conductor increases very rapidly due to cooling so that it becomes practically an insulator.

My invention will be more fully set forth in the following description referring to the accompanying drawing, 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 drawing, Fig. 1 is an elevation-al view partly in section of an electric circuit breaker embodying the present invention, Fig. 2 is a similar view showing another form my invention may assume, and Fig. 3 is a partly diagrammatic view illustrating a gas blast circuit breaker in another form of my invention.

Fig. 1 illustrates the application of the present invention to a high voltage circuit breaker of the gas blast type including a separate source of pressure such as a storage tank or compressor for example. Operable within the main switch chamber 1 is a movable rod contact 2 connected as at 2' with one terminal of the breaker. The chamber 1 is arranged to be in communication with the source of gas pressure at 3. At the upper part of the chamber 1 is an insulating nozzle 4 at the exhaust of which is positioned the fixed contact 5 connected to the other terminal for coacting with the rod contact 2. At the exhaust of the chamber there is positioned the usual muffler and gas cooling structure 6. The circuit breaker so far described is of the well-known gas blast type, the opening operation being effected simply by lowering of the rod contact 2 coincident with admission of gas under pressure to the chamber 1. When the arc is drawn within the restricted part of the nozzle 4, interruption of the arc by the gas blast takes place.

For the purpose of damping the recovery voltage in the manner above referred to, there are connected parallel to the switch chamber 1 and across the breaker terminals two or more tubes 7 composed preferably of material such as fibre adapted to vaporize a certain extent and give off gas under the influence of heat. These tubes are connected with the exhaust part of the chamber 1 by means of conduits 8 so that they are filled with hot arc gases practically immediately after initiation of the interrupting operation. The openings of the gas outlets 8 preferably are at the fixed contact 5 as illustrated so that hot arc gases can flow into the tubes 7 from the very instant of contact separation. The lower ends of the tubes 7 exhaust in each case into a chamber 9 having walls composed of conducting material

that are also electrically connected through a conductor 10 to an intermediate contact 11.

During the arc interrupting process, the hot arc gases flow into the tube 7, and due to their conductivity in the hot state, form parallel connections with the interrupting gap 5-11. That is, the conducting gas columns serve as shunting resistors. After the passage of the current through zero, the parallel connection is automatically interrupted, for example, by the cooling off and deionization of the gas columns. In cooling, the gas rapidly approaches the insulation value of air. The cooling action is aided by the vaporizing action along the inner walls of the tubes 7. The circuit breaker as shown is in the intermediate position wherein the arc is interrupted and the gas column cooled. The rod contact may subsequently be moved further downward to separate from the intermediate contact 11 so as to relieve electrostatic stress in the tubes 7.

Although I have shown my invention as applied specifically to gas columns, it shall be understood that materials which conduct in the hot state and lose their conductivity upon cooling may be used as desired. To this class of materials belong, for example, ceramic substances. Ceramic substances, particularly all bar-shaped bodies or bodies otherwise having a cross-section for approximately constant current passage consisting of sintered metal oxides such as  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$  may be used. Also other substances are contemplated, such as for example sulphides or halogen compounds such as  $\text{CaF}_2$ , as well as sintered mixtures or solid solutions of such substances. Their suitability for current carrying in the hot state as well as for the rapid suppression of current upon cooling has been proved in high voltage fuses which are filled with granular extinguishing medium. These substances have substantially higher absorption capacity for heat than cold conductors and therefore must have substantially less volume for rapid cooling.

Furthermore, by my improved method the circuit interrupting operation may take place within less time, since upon disappearance of the main arc current and after the maximum voltage value is reached, the circuit is completely and automatically cleared, whereas in the case of cold conductors, such as metallic resistors, the reduced current has in the past been subsequently interrupted by a series switch in order completely to clear the circuit.

Preferably, by reason of availability and simplicity of operation, gas columns are used along paths limited by narrow tubes which, compared with the interrupting arc are of appreciable length. In order to insure a sufficient damping of the recovery voltage, however, the total cross-section of these columns may need to be increased. This can be effected by parallel connections of a plurality of such gas columns. However, each individual column is preferably of approximately 3 mm. or less.

In the case of gas columns of the character described in connection with Fig. 1, that is, thermionized gases at high pressure (super-atmospheric), the gas columns are composed mainly of the gaseous switching products attending an interruption of a high current arc by a gas blast. In such cases, the gases are particularly available in case of heavy overload or short circuit interruptions which generally constitute the most difficult interrupting operations.

The gas blast current interrupting scheme above described also has application to circuit

controlling methods such as the well-known Marx valve system for current rectification.

In another form of gas blast switch wherein the interrupting gas is evolved from the walls of the switch chamber by the heat of the arc itself, it has been found that the gas columns so formed are initially current conducting but rapidly de-ionize due to heat transfer and cooling without breaking down under the recovery voltage. Furthermore, the gases have a sufficiently large volume so that the residual current energy supply is not sufficient for reheating. The heat transfer is accomplished by bringing the gases into contact with large surfaces of solid materials, which through heat transfer or through gas generation due to evaporation of the material, rapidly reduces the temperature of the gas column.

A specific embodiment of this type of switch is shown by Fig. 2 wherein the movable and stationary contacts 2 and 5 respectively coast generally in the manner previously described. Contact 2 in the present case comprises a tubular rod slidable over an insulating rod or bolt 5' centrally positioned with respect to the fixed contact 5. Upon opening of the switch, the arc acts on the adjacent walls of the switch chamber to generate an arc interrupting gas. In the specific arrangement shown, the extinguishing tube 12 composed of an insulating gas-emitting material such as fibre or a synthetic resin for example, is closed at its lower end by the movable contact 2 so that the hot switch gases must flow from the upper chamber 13 into the parallel tubes 7 which are also composed of insulating gas emitting material of the character above referred to. The tubes 7 are arranged circumferentially with respect to the extinguishing tube 12 and terminate at their lower ends in a chamber 9 having conducting walls forming a part of the intermediate contact 11. It will be noted that the operation is essentially the same as in the case of Fig. 1 except that the gas columns are formed by gases generated within the switch itself. For the purpose of facilitating high current interruptions, intermediate exhaust vents 14 are provided in the extinguishing tube 12.

In the case of Figs. 1 and 2, the gas as supplied to the parallel tubes can conveniently be diverted from the total gas flow through relatively narrow supply tubes. The amount of heat supplied is thereby relatively small, so that cooling of the switch section takes place very rapidly. This is particularly important in the case of high voltage switches wherein the gases can be inducted from the hottest points of the switch chamber, particularly from the direct vicinity of the basic points of the arc. If desired, the tubes can be closed at the ends opposite the intake by means of elastic pistons or by pressure responsive valves for example which permit the gases to move through the tubes. Bleed vents can also be provided as at 9' in the chambers 9 for ventilation purposes.

In the arrangement shown by Fig. 3, a mechanical compressor for producing a gas blast is used in combination with gas emitting materials that also may be used for auxiliary arc interruption. The compressor, which is actuated in accordance with operation of the switch through a suitable connection 15', comprises a piston 15 operable under spring bias within a cylinder 16 so as to deliver gas under pressure to the switch chamber 1 when the piston is re-

leased by suitable tripping means indicated at 15". The switch chamber 1 is directly connected at 18 with the intake opening of the tube 7 so that the hot switch gases can pass from the chamber to the tube 7 to exhaust through the metallic muffler device 6. The exhaust part of the tube 7, i. e. at the muffler 6, is electrically connected to the fixed contact 5 as indicated so that the tube 7 is in shunt with the interrupting gap 5-11. For the purpose of limiting the current in this shunt connection, a series resistance 7' of suitable value can be provided as shown.

In order to further increase the gas discharge of the tube 7, a concentric pin or bolt 17 that consists, as in the case of the tube 7, of material adapted to vaporize and give off gas under action of the hot arc gases extends parallel to the gas flow. The effective cross-section of the tube 7 is preferably dimensioned so that in the case of high currents, any "arc-back" that may take place would be extinguished by the gas generated by the arc within the tube itself. The main or primary arc in the chamber 1 between contacts 2 and 5 has in the meantime been interrupted as in the manner of Fig. 1 and re-ignition of the arc at that point is prevented by the gas blast from the cylinder 16. In order to prevent return of hot gases to the chamber 1 in such a case, a check valve 18' can be positioned between the chamber and the tube 7. A particular feature of this design is that the supply of gas from the cylinder 16 serves practically instantly to cool and de-ionize the gas column at 7 upon interruption of arcing in the chamber 1.

In another practical application of this same design, the gas blast contacts at 2 and 5 are relied upon mainly for low or moderate current interruptions and the interrupting duty at large currents is taken over by the extinguishing tube 7 provided with gas-emitting arc chamber walls. In this case the main gas blast serves in sequence for two interrupting chambers.

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 interrupter comprising means for defining an interrupting arc gap, means for causing flow of gas through said gap for interrupting the arc therein, and means including an insulating tube for leading heated gas from a point in said gap adjacent said arc so as to be electrically connected across the terminals of said interrupter and electrically to shunt said gap as a damping resistance.

2. An electric air circuit interrupter comprising means for defining an interrupting arc gap, means for extinguishing the arc formed at said gap, and means for diverting during the extinguishing operation heated arc gases from said gap along a path electrically connected in parallel with said gap across the interrupter terminals so as to form a damping resistance having a negative temperature coefficient of resistance.

3. An electric air circuit interrupter comprising means for forming an interrupting gap in which the arc is interrupted, means forming a plurality of insulating passages electrically connected in shunt with said gap for diverting heated arc gases from a point adjacent said arc,

said passages each being approximately three millimeters in diameter, and conducting means associated with opposite ends of said passages and electrically connected to the terminals of said gap respectively whereby the plurality of gas columns in said passages serve as a damping resistance having a negative temperature coefficient of resistance.

4. An electric air circuit interrupter comprising means for defining an interrupting arc gap in which the arc is interrupted, and means for leading heated arc gases from said gap adjacent said arc so as to be electrically connected across the terminals of said interrupter and electrically to shunt said gap as a damping resistance having a negative temperature coefficient of resistance, the length of the shunting gas passage being appreciably longer than the length of said arc.

5. An electric air circuit interrupter comprising means for defining an interrupting arc gap, means for diverting heated arc gases from said gap along a passage electrically connected in parallel with said gap across the terminals of the interrupter so that the gas column in said passage functions as a damping resistance having a negative temperature coefficient of resistance, the walls of said passage being composed of a material adapted to emit gas under influence of the arc heat.

6. A gas blast circuit breaker comprising an interrupting chamber, relatively movable contacts operable in said chamber to form an interrupting gap, means for directing gas under pressure through said gap for interrupting arcing, means forming insulating passages for diverting heated arc gases from said chamber adjacent one of said contacts so as to shunt said interrupting gap, and a chamber into which said diverted gases are directed having conducting wall structure electrically connected to another of said contacts whereby said contacts are shunted by a heated gas column constituting a damping resistance having a negative temperature coefficient of resistance.

7. An electric circuit breaker comprising relatively movable contacts separable to form an interrupting gap, a closely confining interrupting chamber in which said contacts operate, the walls of said chamber being composed of an insulating material adapted to emit an arc interrupting gas under influence of the arc heat, and means for diverting heated arc gases from the region of the arc along a path parallel to said interrupting gap comprising insulating means forming a plurality of passages parallel to said interrupting chamber, said passages at the opposite ends thereof being in communication with gas chambers having conducting wall structure adapted to be electrically connected to said contacts respectively whereby the gas columns in said passages constitute a damping resistance having a negative temperature coefficient of resistance.

8. A gas blast circuit breaker comprising relatively movable contacts separable to form an interrupting gap, means for directing a gas under pressure through said gap to interrupt arcing, means forming an insulating passage through which the heated gas blast from said gap is directed, the entrance of said passage being defined by means electrically connected to one of said contacts, the exhaust portion of said passage being defined by means electrically connected to another of said contacts whereby heated gas exhaust forms a hot conductor connected in par-

allel with said gap constituting a damping resistance having a negative temperature coefficient of resistance.

9. A gas blast circuit breaker comprising relatively movable contacts separable to form an interrupting gap, means for directing a gas blast under pressure through said gap to interrupt arcing, means forming an insulating passage through which heated gas from said arc gap is directed, means electrically connecting said passage across the terminals of said breaker and said gap so that the hot gas in said passage forms a damping resistance in shunt with said gap during arcing, the gas in said passage being quickly cooled and de-ionized by said blast to form an insulator upon arc interruption.

10. A gas blast circuit breaker comprising relatively movable contacts separable to form an interrupting gap, means for directing a gas under pressure through said gap to interrupt arcing, means forming an insulating passage through which heated gases from said gap are directed, the entrance of said passage being defined by means electrically connected to one of said contacts, the exhaust portion of said passage being defined by means electrically connected through a resistance to another of said contacts whereby said passage constitutes an auxiliary interrupting chamber and the hot gases therein constitute a damping resistance in shunt with said gap.

11. Electric alternating current circuit controlling means for establishing and interrupting

electric current comprising means for forming an interrupting gap, means for directing a gas blast through said gap, and means for directing gas from said gap along a separate path electrically shunting said gap throughout its length so that heated arc gases in said path constitute a damping resistance characterized by a negative temperature coefficient of resistance and rapid cooling.

12. An electric circuit interrupter comprising means forming an interrupting gap, a damping resistance circuit arranged to be electrically connected in shunt with said gap including a gaseous path and a metallic resistance connected in series therewith, and means for directing heated arc gases from said interrupting gap to said gaseous path.

13. An electric circuit breaker of the gas blast type comprising separable contacts adapted to form an interrupting gap, an arc chamber in which said gap is formed, means for directing a gas blast into said chamber and through said interrupting gap to exhaust from said chamber, a second chamber for receiving the exhaust blast from said arc chamber, said second chamber having terminals of conducting material, and means for electrically connecting said terminals with said separable contacts respectively so that the gaseous body in said second chamber is electrically connected in shunt with said interrupting gap.

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