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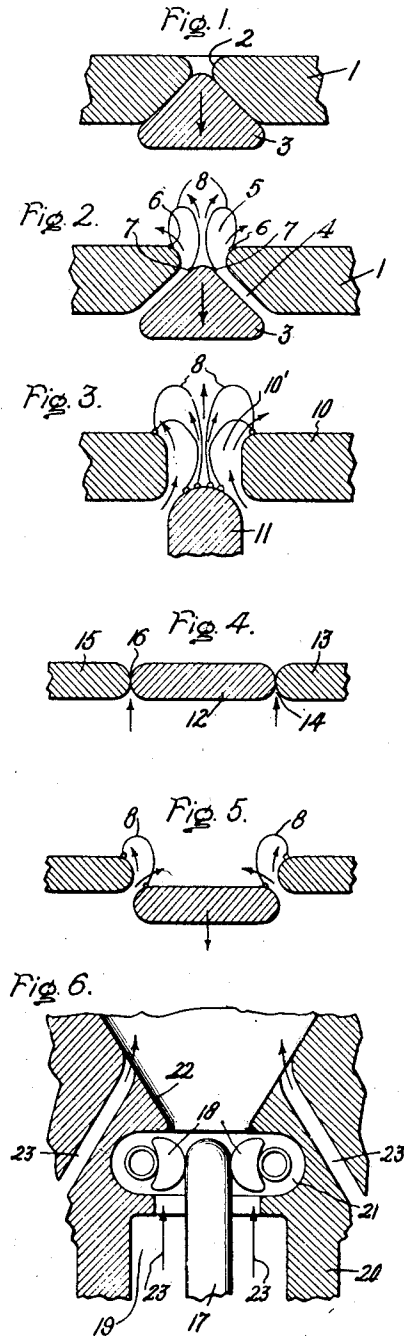
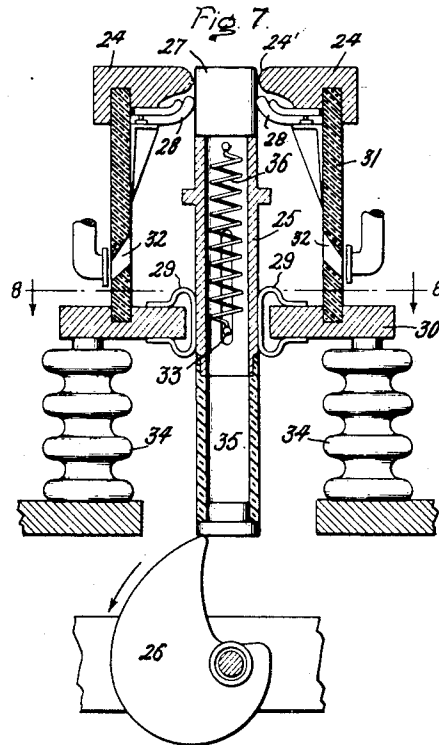
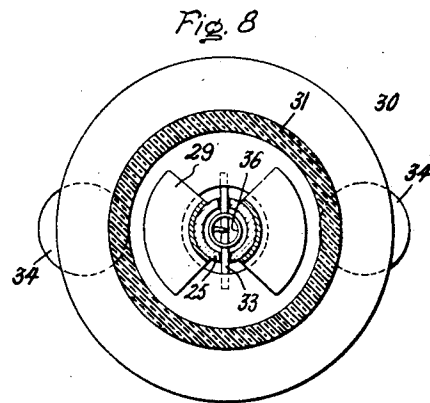
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METHOD AND APPARATUS FOR INTERRUPTING HIGH TENSION CIRCUITS

Filed Sept. 3, 1927

3 Sheets-Sheet 1



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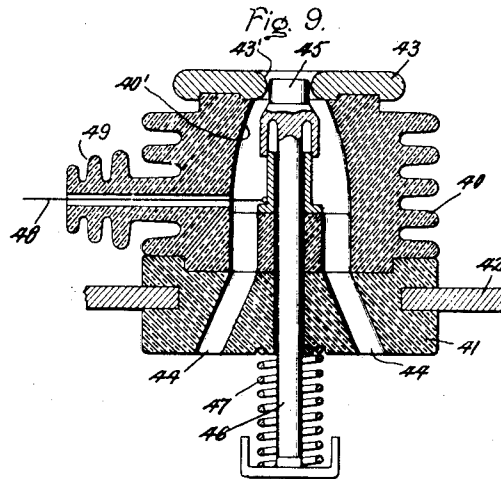
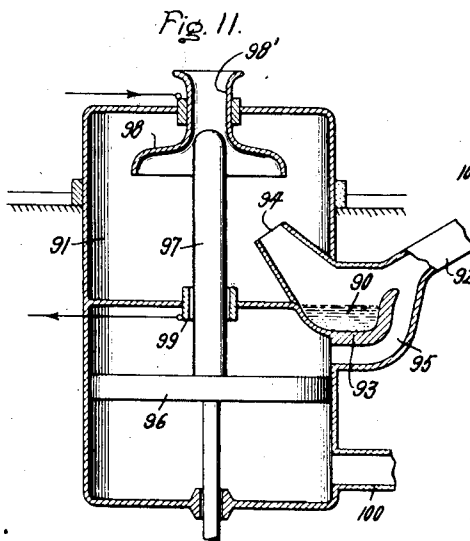
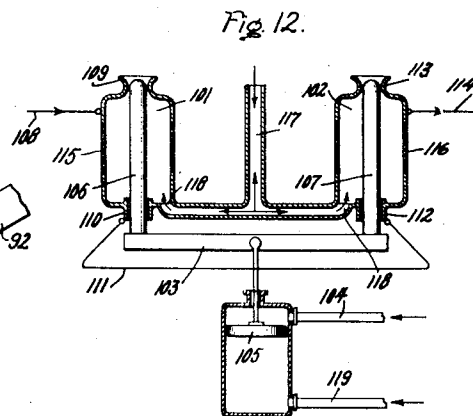
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METHOD AND APPARATUS FOR INTERRUPTING HIGH TENSION CIRCUITS

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3 Sheets-Sheet 2



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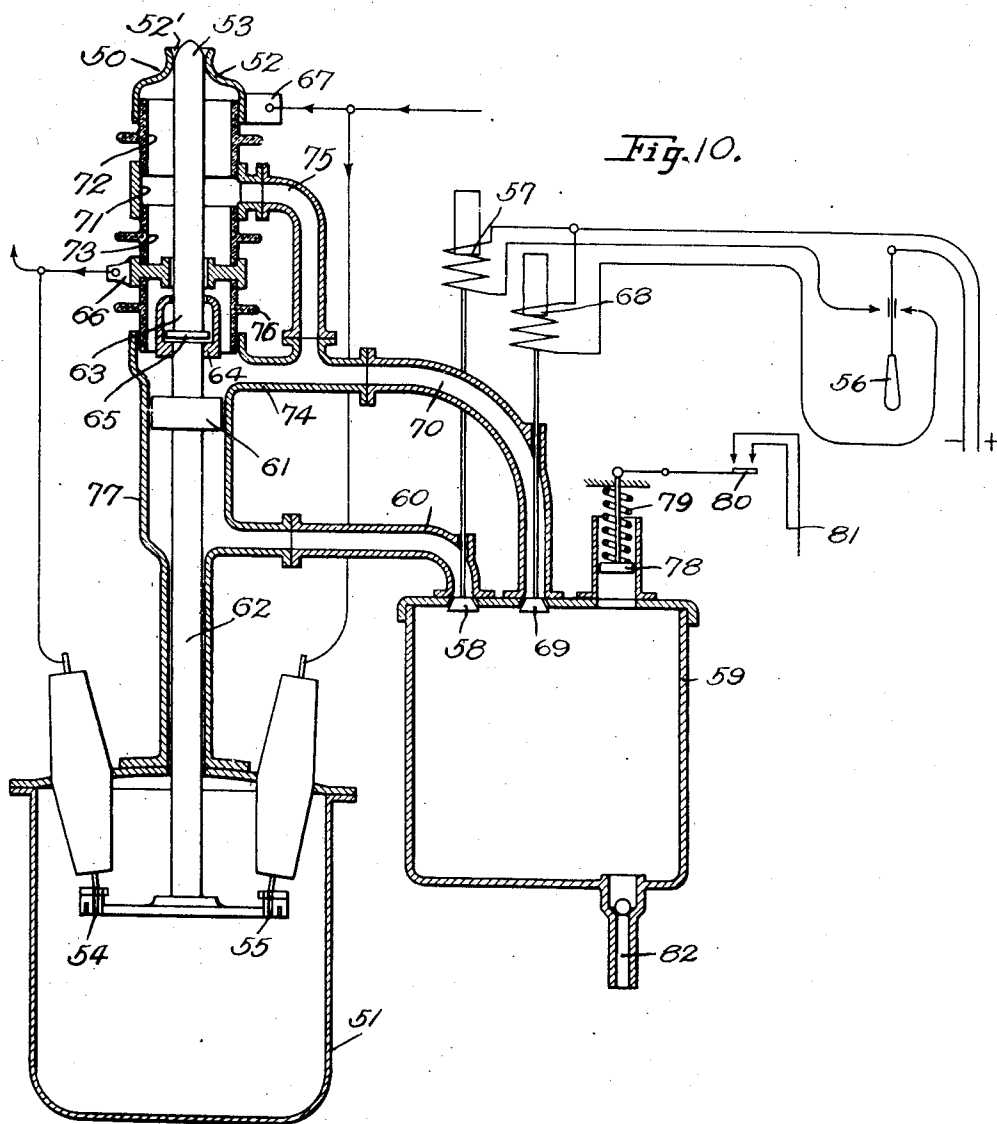
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METHOD AND APPARATUS FOR INTERRUPTING HIGH TENSION CIRCUITS

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR INTERRUPTING HIGH TENSION CIRCUITS

Application filed September 3, 1927, Serial No. 217,438, and in Germany May 18, 1925.

My invention relates to a method of and apparatus for interrupting high tension circuits, more particularly to the interruption of a high tension, alternating current power arc by means of a blast of gas.

It has been proposed to cool the electrodes or contacts of circuit breakers, between which arcing occurs, for the purpose of dissipating the large amount of heat generated and for cooling the points of origin of the arc during circuit interruption. Various arrangements heretofore proposed along this line have been unsuccessful due to the fact that the cooling action did not take into account the tendency of the arc to persist.

It has further been proposed to quench the arc by blowing, as by injecting air into the gap between the electrodes, but these proposals likewise have proved unsuccessful in so far as high tension electric circuit breakers for power currents are concerned. A high voltage arc, involving correspondingly high velocity of the ions in the arc stream, is far more resistive to the action of a gas or air current than a comparatively weak, low voltage arc. This is one of the reasons that the quenching or interruption of high tension power arcs by means of air under comparatively low pressure has failed. In the case of gas or air at low pressure, the velocity of the gas is not sufficient to carry the ions and electrons out of the arc path and to tear the arc bodily from the arc gap. The arc, as above referred to, may be considered a dense and rapidly moving chain of ions formed at the high voltage existing across the circuit breaker terminals.

A principal object of my invention is the provision of an improved method of and apparatus for interrupting high tension circuits by means of a suitably directed gas blast.

I have found that gas or air under high pressure and in a suitably confined and directed current will act on an arc in several ways, one way being through the velocity attained by the gas when expanding under the influence of pressure. This high velocity of expanding gas results in a cooling action during expansion, a cooling action by

way of exchange of gas, that is, the hot gas surrounding the arc being replaced by cold gas, and a cooling action by the evaporation of any liquid present in consequence of a change of pressure during the flow of the gas; the aforesaid evaporation of liquid admixed with the gas having an action similar to that utilized in refrigerating apparatus.

The high velocity of the gas under pressure will further exert a tearing force on the arc and its points of origin on the electrodes so as to carry the electrons and ions away from the electrodes and the arc path itself.

Another way in which the gas acts on the arcs involves the insulating or dielectric properties of the gas. The gas under pressure will also have an insulating effect between the electrodes in view of the fact that gas under high pressure also possesses higher dielectric strength and therefore renders "back firing", or reestablishment of arcing through the gas stream, difficult or impossible.

The cooling action on the arc of the gas under high pressure is the result of several effects, one of which is the cooling action on the electrodes themselves. The electrodes are cooled in different places by the gas stream. If the strength and the velocity of the gas stream are sufficiently great to move the arc, which tends to stick to a hot point on a corresponding electrode, the arc is drawn out or stretched and the density of ions is reduced until the arc is torn by the mechanical force acting thereon. In other words, the arc stream, including the ions and metal evaporated from the electrodes by the heat of the arc, is stretched and diluted by the gas, the thinner the arc the less force being required for tearing or stretching the same.

Into the gas formed upon tearing or displacement of the arc, a layer of compressed gas having high dielectric strength is inserted. While this is taking place, however, the gas under pressure moving with great velocity tends to displace the points of arc origin on the electrodes so as to shift the arc onto cooler parts of the electrodes. The

electrons there formed, the velocity of which is dependent upon the voltage, are torn away by the gas stream provided the velocity of the gas is sufficient. The electrons cannot directly cross the gas stream and will move in a direction defined by two components; i. e., the velocity of the gas and the velocity of the electrons. At a corresponding position along this component of direction, the size and shape of the electrodes will determine whether a sufficient number of ions can still travel from one electrode to the other so as to sustain the arc. The point of origin or formation of the arc, having shifted under the influence of pressure, will not be capable of vaporizing at the former rate the comparatively cold metal of the electrodes and therefore no new masses of ions can form, more particularly in view of the fact that the number of ions has been reduced by the gas stream. This effect is further enhanced in a circuit breaker by the fact that the electrodes are relatively movable so as to move away from each other upon interruption of the circuit. Accordingly, after a certain degree of separation of the electrodes, the gap between them cannot be bridged by ions even if no electrical blocking of the gap has been effected by the gas under pressure. The purely mechanical elongation of the arc by the switching operation likewise acts so as to weaken the arc by diminishing the density of ions. When the switch starts its opening movement, the arc is still short and strong and during this time the gas under pressure will flow through the arc gap with the greatest power per unit of length of the arc. The arc is thereby elongated and the force of the stream of the compressed gas is now directed mainly onto the points of formation of the arc.

In accordance with my invention the gas under pressure is confined within a comparatively narrow space, as for example by causing the gas under pressure to travel in a sleeve or annular passage or the like so that sidewise movement of the arc is prevented and the necessary velocity of the gas at the points of origin of the arc within the arc gap is obtained. In a device constructed in accordance with the present invention the electrodes may be formed so that one electrode surrounds the other, the surrounding electrode having a diverging exhaust passage at the restricted portion of which the other electrode coacts.

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, Figs. 1 to 5,

inclusive, are diagrammatic illustrations of various electrode arrangements; Fig. 6 is a fragmentary view, partly in section, of circuit breaker electrode structure embodying my invention; Fig. 7 is an elevational view, partly in section, of a gas blast circuit breaker and operating means therefor; Fig. 8 is a sectional view, taken along the line 8-8 of Fig. 7; Fig. 9 is a view, partly in section, showing another form of gas blast switch; Fig. 10 is a partly diagrammatic illustration of a complete gas blast circuit breaker and associated operating and controlling means; Fig. 11 is a view, partly in section, of another form of gas blast circuit breaker using an additional arc extinguishing fluid, and Fig. 12 is a view, partly in section, of a double pole gas blast circuit breaker and its operating means.

Referring to Fig. 1 of the drawings, there is shown a surrounding electrode 1 having a funnel-shaped or nozzle-like perforation or opening 2 in which the conical shaped electrode 3 coacts. When the electrodes 1 and 3 are in engagement the contact surfaces thereof engage along the inner wall of the nozzle-like passage 2 so as to close the same. If now, referring to Fig. 2, the electrode 3 is moved in the direction of the arc formed between said electrodes and gas under high pressure is directed across the arc gap now formed between the electrodes and through the nozzle-like passage 2 so as to exhaust in the manner indicated, the arc will at once be elongated and subjected to the tearing effect of the gas blast. The gas flow is clearly indicated in Fig. 2, the gas flowing past the electrode 3 through the annular passage 4 and exhausting as at 5 in the general direction of the indicating arrows. The gas which flows through the gap between the electrodes with great force and velocity acts on the arc formed between the points 6 and 7 so as to carry along with it these points which are the formation or origin points of the arc. The tendency is, therefore, to prevent reestablishment of arcing since the entire contacting surfaces of the electrodes are actively cooled and the arc has little opportunity for sufficiently heating the electrode metal at any point.

At the same time the density of the ions of the arc stream 8 is greatly diminished by reason of the elongation of the arc which is also brought about by the opening of the electrode 3 in the direction indicated, which is substantially longitudinal of and counter to the gas flow. The arc will be torn and extinguished under all circumstances at the moment when the velocity of the gas has increased far beyond the velocity of the ions so that an ion torn away at one electrode, as for example electrode 3, cannot traverse the gas stream to reach the other arcing surface upon the electrode 1. The resultant

component of the ion velocity and gas velocity will be directed increasingly in the direction of the gas current until the arc is actually torn and extinguished.

5 The arrangement illustrated in Fig. 3 involves similar phenomena. In this case the gap between the two parts of the electrode 10 is wider and the points of formation or origin of the arc on the electrode 11, therefore, travel from the sides of said electrode towards its tip, tending to unite at a single point. These origin points of the arc are particularly exposed to the blasting action of the gas under pressure exhausting through the opening 10'. Accordingly, if 15 the tip of the electrode 11 is covered with insulating material in the form of a layer of gas under pressure, the arc simply will be torn off at this point. As in the previous instance, the arc stream 8 is stretched and elongated by the gas blast directed through the opening 10' and is extinguished in the same general manner.

Figs. 4 and 5 illustrate another form of electrodes having two points of interruption, the intermediate electrode 12 making contact with an electrode 13 at a point 14, and with an electrode 15 at 16. When the electrodes are separated, gas under pressure is forced across the gaps at 14 and 16 as illustrated in Fig. 5, the gas blast acting on the arcs substantially as described with reference to preceding figures.

Fig. 6 illustrates a form of circuit breaker 35 which embodies the above described principles of operation. The electrode 17, which in the present instance is rod-like in form and may be movable with respect to the contacting electrode structure 18, is longitudinally movable into and out of contacting engagement with the aforesaid electrode structure within a bore 19 formed in an enclosing casing 20. The enclosing sleeve or casing 20 is provided with an annular recess 21 in 45 which the stationary electrode structure 18 is disposed and a diverging exhaust passage 22 which is in communication with the bore 19 when the aforesaid electrodes are separated. The stationary electrode structure 50 18, which may be of the segmental or other suitable type, is substantially at the restricted portion of the diverging exhaust passage 22 so that when gas is directed under high pressure through the bore 19, as indicated by the arrows 23, separation of the electrode 55 surfaces takes place at the point of maximum velocity of the gas. Upon downward or opening movement of the rod electrode 17, gas at high pressure is directed, as indicated, through the bore 19, and the arc gap between the electrodes 17 and 18 to exhaust through the diverging passage 22, it being noted that the gas approaches the arc gap along a generally converging path and 65 leaves the arc gap along a generally diverg-

ing path. For the purpose of increasing the effect of the gas blast borings 23 may be provided, if desired, for admitting gas under pressure into the exhaust passage and creating an aspirating effect as indicated. The arc between the electrodes 17 and 18 is extinguished by the gas blast generally in the manner previously described. 70

In Figs. 7 and 8 there is shown a gas blast circuit breaker including relatively movable 75 electrodes 24 and 25 and a rotatable cam 26 for operating the movable electrode. The stationary electrode 24 is provided with an exhaust opening 24' in which the contact tip 27 of the movable electrode 25 coacts. As 80 shown, the coacting electrodes engage substantially at the more restricted portion of the passage 24'. For the purpose of increasing the current-carrying capacity of the electrodes, spring contacts 28 connected to the stationary electrode 24 are provided so as to engage one end of the electrode 25, and spring contacts 29 electrically connected to the stationary terminal 30 are provided so as 85 to make sliding contact with the other end of the movable electrode. For the purpose of supporting the stationary electrode 24 and for providing a confining passage or gas chamber for gas directed to the arc gap, an insulating cylinder 31 of suitable material is 90 provided and is disposed between the electrode 24 and terminal 30. Gas from a suitable source of pressure may be directed into the gas chamber formed by the insulator 31 by way of apertures 32. 95

The supporting means for the movable electrode 25 comprises a pin 33 secured to the terminal 30, which is in turn supported by the insulators 34. The lower part of the electrode 25 comprises an insulating tube 35 105 arranged to be engaged by the operating surface of the cam 26, the cam normally holding the electrode 25 in the closed circuit position. Opening of the switch is effected by movement of cam 26 in counter-clockwise 110 direction, as indicated, so that the spring 36, which is connected at one end to the electrode 25 and at the other end to the pin 33, is effective to retract the electrode 25 causing separation of the coacting electrode surfaces. 115 At the same time gas under high pressure is directed through the openings 32 and across the arc gap formed between the electrodes to exhaust through the opening 24' and extinguish the arc in the manner previously described. Closing of the switch is effected by continued rotation of the cam 26 so that the electrode 25 is projected upwardly to the closed circuit position shown, thereby placing the spring 36 under tension and in readiness for a subsequent opening operation. 120

Referring to Fig. 9, there is illustrated another form of gas blast switch comprising a hollow insulator 40, an insulating base plate 41 and a supporting ring 42. The sta- 130

tionary electrode 43 is mounted at the upper part of insulator 40 and is provided with a nozzle-like exhaust opening 43' communicating with the hollow bore 40' which together with the communicating passages 44 define a gas passage leading to the arc gap. The movable electrode 45, which coacts with electrode 43 within the opening 43', is provided with an operating stem 46 biased as desired by a spring 47. Operating means (not shown) are provided to obtain desired movement of the electrode 45. The movable electrode 45 is suitably connected to an exterior terminal by a conductor 48 mounted in an extension 49 of the insulator 40. Upon downward or opening movement of the electrode 45, gas is directed through the openings 44 and 40', to exhaust through the opening 43' across the arc gap formed therein, thereby extinguishing the arc in the manner previously described.

Fig. 10 discloses a complete gas blast circuit breaker connected in parallel with an oil circuit breaker, for example, and provided with gas pressure supply and control means. It will be understood, of course, that the oil circuit breaker is not an essential part of the arrangement shown. In the present instance the gas blast circuit breaker 50 is connected to the oil circuit breaker 51 in such a manner that upon closing of the device the electrodes 52 and 53 of the gas blast switch are closed subsequent to closing of the contacts 54 and 55 of the oil circuit breaker, and upon opening the device the gas blast switch has the duty of interrupting arcing.

Referring more particularly to the control arrangement, movement of the control lever 56 to the left causes energization of coil 57 and consequent opening of the valve 58. The valve 58 controls flow of gas from the gas tank 59, which contains a suitable supply of gas at high pressure. Opening of the valve 58 admits gas under pressure to the pipe 60 so as to force upwardly piston 61, closing both the oil switch and the gas switch.

To this end the piston rod 62, which is directly connected to the contacts of the oil switch 51, has a lost motion connection with the upper portion of the rod 63 as illustrated. The rod 62 has secured to its upper end a cup-shaped member 64 in which the rod 63 is slidably guided, the upper intumed edge of the member 64 being arranged to engage a collar 65 forming a part of the rod 63. The rod 63, which is of conducting material and comprises the movable electrode 53, is in sliding conducting engagement with a current collecting ring 66 forming one terminal of the gas switch. The other terminal of the switch comprises a conducting lug, or the like, connected to the nozzle-like electrode 52 so that in the position shown the

circuit is continuous between terminals 66 and 67.

When the device is to be opened the control switch 56 is moved to the right, energizing the opening coil 68 and causing opening of the valve 69. Gas under pressure from the supply tank 59 is admitted by means of the pipe 70 to the gas blast switch so as to effect downward movement of the piston 61. This causes immediate opening of the contacts 54 and 55 of the oil switch and subsequent opening, by reason of the lost motion connection above described, of the movable rod electrode 53. It will be apparent that this sequence of opening imposes the duty of extinguishing the arc on the gas blast switch, the oil switch serving to carry the main current.

For the purpose of also directing the gas under pressure from the pipe 70 to the arc and providing a passage or chamber therefor, the switch casing of the gas blast switch 50 comprises an intermediate metallic section or casing 71 at the opposite ends of which hollow insulating members or shells 72 and 73 are disposed. The nozzle-like electrode 52 is mounted at the upper part of the insulator 72 and the lower part of the insulator 73 is suitably closed, as by the current collecting ring 66, so as to form a gas chamber in communication with the exhaust opening 52' of the electrode 52. The metallic gas supply pipe 70 includes two branches, one branch 74 arranged to direct gas to the upper side of the piston 61 and the other branch 75, which is directly connected to the intermediate metallic section 71, arranged to direct gas for the arc extinguishing blast into the chamber formed by the switch casing of switch 50. The lower end of the switch casing comprises an insulating shell 76 housing the aforesaid lost motion connection and mounted on a conduit section 77 which communicates with the pipe 60.

Since the gas under pressure is directed to the piston 61 and gas chamber of the switch 50 at the same time, it will be apparent that gas under pressure is immediately available to extinguish the arc formed upon separation of the electrodes 52 and 53. As the rod electrode 53 is withdrawn into the switch casing, the gas under pressure traverses at high velocity the annular arc gap at the restricted portion of the opening 52' so as to blast the arc through the comparatively short and diverging passage and extinguish the same.

If desired, a pressure responsive piston 78 normally biased, as by a spring 79, against the gas pressure in the tank 59 may be arranged so as to interrupt the circuit of the control switch 56, thereby preventing operation of the gas blast switch when the pressure in the supply tank is too low. To this

end a switch 80 may be connected to the piston 78 so as to be normally open or closed as desired. It will be apparent that the switch 80 might also serve for refilling the gas supply tank 59 in case of unduly low pressure. In this case a circuit 81 may be closed by the switch 80 upon a predetermined decrease of gas pressure so as to operate a compressor (not shown) for refilling the supply tank 59, as by way of the valve controlled pipe 82. Or, if desired, the control circuit 81 may be arranged to cause opening of a valve leading to another gas supply container.

It will be apparent that the piston 61 may be directly connected to the movable electrode 53 so as to cause operation of the gas blast switch independently of the oil switch 51. The control switch 56 permits selective control of the closing and opening valves, subject, of course, to the gas supply pressure responsive device when such is used.

Fig. 11 illustrates a gas blast switch provided with means for introducing another arc extinguishing fluid into the arc during the gas blast. To this end a substance 90, which may be either vaporizable or explosive in character, is, by way of example, directed or disposed in the path of the gas blast so as to be picked up by the gas and carried with it through the arc gap. The arc extinguishing fluid 90 may comprise water, oil, liquid air or another refrigerating medium, or a substance which serves to aid the interrupting action of the gas blast. The gas blast is directed into the switch casing 91 through a pipe 92 which is provided at its entrance to the switch with a cup 93 which contains the arc extinguishing fluid 90. The pipe 92 terminates in an up-turned nozzle 94 directed towards the arc gap and a branch passage 95 for admitting gas to the operating piston 96 to which is connected the movable electrode 97. A stationary electrode 98 having a gas exhaust passage 98' forms one terminal of the switch, the electrode 97 being suitably connected to the other terminal as by a guiding conducting ring 99. Gas for closing the switch may be directed to the lower side of the piston 96 through the pipe 100.

Upon admission of gas under pressure to the pipe 92, the electrodes are at once separated by downward movement of the piston 96 and a high velocity gas, together with the arc extinguishing fluid 90, either in liquid or vaporized form, traverse the arc gap at high velocity and exhaust through opening 98' to extinguish arcing.

Fig. 12 illustrates a double pole gas blast switch, the separate poles 101 and 102 being interconnected by a bridging member 103. Opening of the switch is effected by admitting gas under pressure to the pipe 104 caus-

ing downward movement of the piston 105 which is suitably connected to the bridging member 103 carrying the movable electrodes 106 and 107. The circuit is completed through the switch by way of the terminal conductor 108, stationary electrode 109, movable electrode 106, conductor ring 110, bridging conductor 111 (in lieu of a conducting bridging member), conductor ring 112, movable electrode 107, and the stationary electrode 113 of the other pole which is connected to the terminal conductor 114. The switch casings 115 and 116, which form the gas chambers of the switches 101 and 102, respectively, are formed of insulating material and have mounted at the upper ends thereof the stationary nozzle-like electrodes 109 and 113, respectively.

Upon opening of the switch, gas is directed by way of pipe 117 into both switch casings through openings 118 concurrently with actuation of the operating piston 105. The two arcs in series are traversed by the gas blast in the manner previously described. The closing of the switch may be effected by admitting gas to the lower side of the piston 105 by way of the pipe 119.

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.

I claim:

1. A high tension circuit interrupter comprising a pair of electrodes, one of said electrodes having a passage defined by a diverging exhaust portion, the other electrode arranged to engage the first-named electrode within said passage and at the restricted portion thereof, and means for directing a gas at high pressure through said restricted portion to traverse the arc formed therein and exhaust through said diverging portion upon separation of said electrodes.

2. A high tension circuit interrupter comprising relatively movable electrodes, one of said electrodes having a passage defined by converging, constricted, and diverging portions, the other electrode having a contact surface for engaging the coacting electrode contact surface within said passage, said contact surfaces being substantially at the constricted portion of said passage, means for separating said electrodes to form a gap within said passage, and means for directing a gas at high pressure across said gap and through said passage so as to blow said arc through said constricted and diverging portions of said passage to cause interruption thereof.

3. A high tension, alternating current circuit interrupter comprising a pair of relatively movable electrodes, one of said electrodes defining a comparatively short and

diverging gas passage, the other electrode coacting with said first-named electrode within said passage, and means for directing a gas at high pressure through said diverging passage to exhaust, said electrodes having arcing surfaces separable upon opening of the circuit substantially at the point of maximum gas velocity in said passage.

4. A high tension circuit interrupter of the gas blast type comprising a pair of electrodes separable to form a passage through which gas at high pressure is directed to extinguish arcing between said electrodes, and means for directing another arc extinguishing substance into the path of said gas prior to its flow through the arc within said passage.

5. A gas blast circuit interrupter comprising an intermediate metallic casing having hollow insulators at opposite ends thereof forming a gas chamber, relatively movable electrodes disposed at one end of said chamber and separable to form a gap through which gas from said chamber may exhaust to interrupt an arc within said gap, metallic pipes connecting said intermediate casing and chamber to a source of gas pressure, and valve structure controlling the flow of gas from said source.

6. A high tension circuit interrupter of the gas blast type comprising electrodes, one of which surrounds the other, separable to form an arc gap through which a gas is directed to extinguish arcing, the shape of said electrodes defining a path upon separation thereof such that said gas approaches said arc gap by a path of decreasing cross section and leaves said gap by a path of increasing cross section directly to a region of low pressure.

In testimony whereof I affix my signature.
SIGWART RUPPEL.

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