

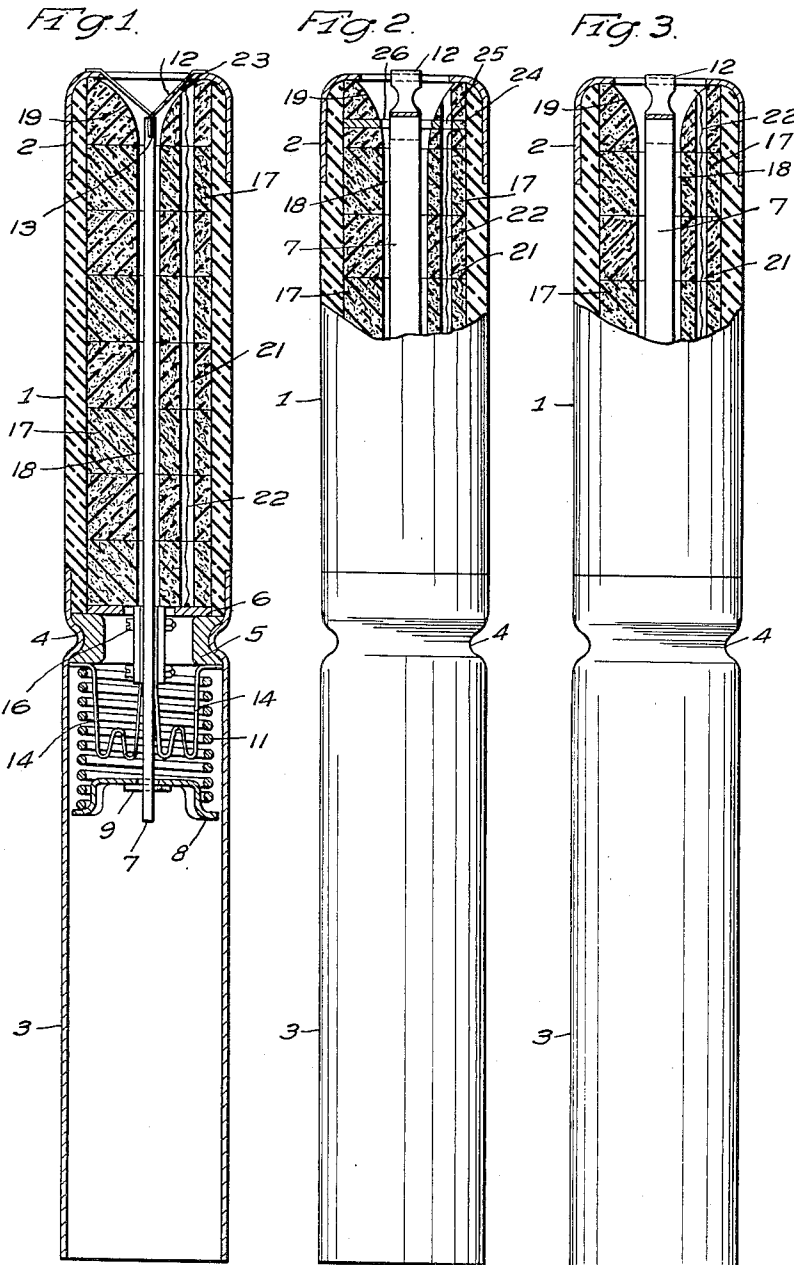
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HIGH POWER FUSE

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## HIGH POWER FUSE

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Our invention relates to current interrupting devices such as switches, fuses, circuit breakers and the like. It has to do particularly with the means for extinguishing the arc. More particularly, this invention relates to that class of arc-extinguishing devices in which a blast of gas is directed into the arc.

In some devices of this class, the arc is caused to traverse a long and narrow passage, the walls of which are of a material which is acted upon by the arc, producing a gas or vapor which is not ionized, and which, mingling with the ionized gas in the arc, assists in extinguishing it. The gas generated within the long and narrow passage can emerge only through the mouth of the passage which preferably is more or less completely closed at one end and open for free passage of the gas at the end where the arc originates.

The longer the arc within the passage, the greater the length of wall influenced by it will be and the smaller the cross section of the passage, the more intimate will be the contact between arc and wall. A large volume of gas will be evolved, therefore, if the passage be small and the length of arc within it large, but under these circumstances the gas pressure developed will be high. At heavy currents, the pressure may be so high that it bursts the tube. It is difficult to design a structure of this type in which the tube will not burst when the current through the arc is heavy. This consideration fixes the upper limit of current values with which this type of interrupting device can be commercially used.

If the passage be of large cross section and the arc be of small length, the contact between it and the walls of the passage will be comparatively ineffective and a relatively small quantity of gas will be evolved. This quantity may be insufficient to put out the arc and the device may fail to interrupt currents for this reason.

Such devices usually have a fusible element, or a current-controlled trip, to initiate the arc by severing the metallic connections through which the current ordinarily goes. A current which is just sufficient to accomplish this will give rise to only a feeble arc and if the passage in which the arc is enclosed is of large cross section, the device will fail to extinguish the arc. This circumstance fixes a lower limit of the current values which can be interrupted by such devices.

It is an object of our invention to produce a device of the class indicated which shall be

capable of extinguishing arcs throughout a greater range of current values.

It is a further object of our invention to provide a current interrupting device which will effectively prevent the re-ignition of the arc after the current reaches zero within a very few half-cycles, even when it does not do so upon the first passage of the current through zero.

It is a further object of our invention to produce a current-interrupting device of the kind employing a gas blast which is capable of interrupting currents only just sufficient to initiate the operation and also capable of interrupting currents corresponding to short-circuit conditions.

We accomplish this result by providing a device in which the arc must pass through two passages extending in parallel through a body of material which is preferably capable of evolving an arc destroying substance under the influence of the arc. One of these passages we make of large cross section and intend that arcs corresponding to heavy currents shall be interrupted therein. The other passage we make of small cross section and arcs corresponding to small currents will be extinguished therein. The arcs are guided into the passages by conductors. In the large passage, we make one of the conductors movable to lengthen the arc. In the small passage, the conductor is a fine wire which is destroyed by the overload current and guides the arc into and along the small passage.

Further objects of our invention will be apparent and the objects already stated will be better understood by reference to the following detailed description and the accompanying drawing, in which

Figure 1 is a longitudinal sectional view of one form of our device,

Fig. 2 is a view, partly in side elevation and partly in longitudinal section of a modification, the plane on which the section is taken being at right angles to that of Fig. 1, and

Fig. 3 is a view, similar to Fig. 2, of another modification.

In the drawing, 1 is a tube of any convenient insulating material, such as fibre, supplied at one end with a metallic ferrule 2 intended to cooperate with clips or other connection devices through which the fuse is applied to the circuit. The other end of the tube is supplied for a similar purpose with a tubular prolongation 3, of brass or other conducting material, secured to the tube 1 by being depressed, as shown at 4, 110

forming a groove which cooperates with a grooved metallic annular member 5.

The member 5 constitutes a support to which the washer 6 is secured. An opening is provided at the central part of the washer through which a conductor 7 extends. The conductor 7 is secured to a flanged member 8 by means of a cotter pin 9. The flange of the member 8 receives the thrust from a spring 11, the other end of this spring acting against the support 5. Thus, the spring 11 tends to move the conductor 7 away from the ferrule 2.

The conductor 7 is held against movement by means of a fusible member 12, secured to the end of the conductor 7 by soldering or by any other suitable attachment. As shown at 13 in Fig. 1, the member 7 has been slitted to receive one part of the member 12. In this form, the fusible member 12 has two parts each extending to the ferrule 2, to which the member 12 is soldered or otherwise secured. While the bifurcated form of the fusible link is preferred, a single link extending to but one point upon the ferrule is permissible.

The electrical connection between the conductor 7 and the tube 3 is through flexible connectors 14 which are attached at one end to the support 5 and are secured at the other end, by clamps 16, to the conductor 7.

Between the washer 6 and the end of the tube which has the ferrule 2, the tube is packed with material 17, which, preferably when exposed to an arc, will give rise to gas or other arc-destroying emanation. This material may be boric acid and may conveniently have the form of cakes or bricks, but many other materials and many other forms are available. For example, the material might be soap stone in cylinders to fit the tube 1 or in disks to be piled into the tube. Alternate discs of Fullerboard and of asbestos soaked in oil is another suitable material. Boric acid is desirable since it gives off water vapor which is non-inflammable and is readily condensed.

A passage 18 extends through this material and accommodates the conductor 7. At the end adjacent the ferrule 2, this passage is flared forming a bell 19 within which the fusible member 12 is located. Another passage 21 also extends through the boric acid or other material from the end abutting against the washer 6 to the end near the ferrule 2. The last named end of the passage 21 is closely adjacent the end of the passage 18 and the mouth of the passage 21 may well be considered as in the bell 19.

In that form of the device shown in Fig. 1, a conductor 22, preferably a fine copper wire, extends through the passage 21 from the disk 6, to which it is soldered or otherwise electrically connected, to the ferrule 2. It may be connected, as shown at 23, directly both to the fusible member 12 and to the ferrule 2 or it may be connected to the ferrule 2 at a point separate from the connection of the fusible member 12 therewith or to the fusible member at a point away from the ferrule 2.

In the form shown in Fig. 2, the upper end of the conductor 22 is soldered or otherwise electrically connected to a washer 24 which is embedded in the material 17 and is provided with an opening 25 in alignment with the passage 21 and with an opening 26 in alignment with the passage 18. The washer 24 is insulated from the ferrule 2 by the material 17 and connected to the washer 6 by the conductor 22.

In the form shown in Fig. 3, the end of the

conductor 22 extends to or projects from the mouth of the passage 21 and is metallically connected only to the washer 6.

In the operation of the device, it is inserted into standard contact making devices forming part of the circuit in which it is to be used, thus establishing current-carrying connections to the ferrule 2 and from the tube 3. Although this device is useful for interrupting direct-current arcs its principal field of usefulness is the interruption of alternating-current arcs. With such arcs the current passes through a zero value during each half-cycle.

The fusible member 12 is thus inserted in the circuit to be protected. When the current in this circuit rises above the value for which this circuit interrupter has been designed, the fusible member will melt at the restricted portion, best illustrated in Figs. 2 and 3. As soon, as the member 12 has melted enough to no longer withstand the force of the spring 11, the conductor 7 moves downwardly under the influence of the spring, thus separating the member 12 into two parts between which an arc is established. There is also a current through the fine wire 22 which is sufficient to melt it and an arc is thus established within the small passage 21.

If the current through the arc is no greater or only slightly greater than that which sufficed to melt the fusible link 12, the fine wire 22 will not be melted instantly. The low resistance connection from ferrule 2 to washer 6 therefore lasts until conductor 7 has moved a considerable distance. This connection will put out whatever arc formed between the ends of the link 12, if it does not actually prevent any arc being formed there.

If the current passes through its zero value before the conductor 22 melts, this conductor will prevent the arc from restriking across the gap between the melted ends of link 12. When the fine wire melts, an arc is established which may begin at the mouth of the passage 21, but most of this arc is within the passage 21. Since the current is small the voltage across the arc in passage 21 will not rise sufficiently to cause a rekindling of the arc across the (now large) gap between the ferrule 2 and the end of moving conductor 7.

This small-current arc is subjected to the gas passing out of the passage 21. Since the passage 21 is closed at the lower end, all the gas evolved by the action of the arc upon the boric acid or other material 17 must pass through the arc to emerge from the passage. Thus, the ionized gas within the arc and the non-ionized gas evolved from the boric acid are thoroughly commingled and the deionizing effect of each particle of the emanation has full opportunity to produce its result. The arc, therefore, is promptly extinguished. Since, in the case just assumed, the current in the arc is small, the amount of gas evolved is also small and the gas pressure will not be sufficient to burst the tube even though the passage is small.

We have found by our experiments that the action occurs as described above so long as the arc-current is so small that more than one and a half cycles is required to melt the conductor 22.

When the fusion of the member 12 is caused by a sudden and great increase in current, the arc which results carries a heavy current even after the two portions of the member 12 have separated. Under these circumstances, the fine wire 22 melts throughout its whole length practically instantaneously, with the result that the

arc in the small passage 21 is practically the whole length of the passage and is, therefore, of high resistance compared with the short arc between the member 12 or the ferrule 2 and the adjacent end of the conductor 7 at the beginning of its movement. The wire 22 may melt so quickly that the arc across the melted ends of link 12 is not extinguished. If extinguished it is rekindled practically instantaneously.

The voltage across the heavy arc at the end of the conductor 7 will therefore be too small to maintain the arc in the small passage 21 and the arc in the passage will thus be extinguished so soon that the gas evolved in the small passage will be of small amount and therefore unlikely to burst the tube.

The arc within the large passage 18 evolves less gas than a similar arc in a smaller hole and does not burst the tube because the passage is of such cross section and length that even for the largest currents all the gas evolved may escape without building up excessive pressures. With very large currents enough gas will ordinarily be evolved during the first half-cycle after the beginning of the arc to prevent the arc from being rekindled when the voltage rises again during the next half-cycle. The quantity of gas evolved in one half-cycle therefore represents the maximum pressure which the tube must be designed to withstand.

Whenever the gas evolved during the first half cycle is not sufficient to extinguish the arc, it is also not sufficient to burst the tube.

The arc will rekindle during the second half-cycle only in those cases in which the current is not great enough to develop the quantity of gas required to extinguish it in the first half-cycle and such a current is too small to develop a gas pressure that will burst the tube, even if it endures for several half-cycles. By the time several half-cycles have elapsed, the spring 11 will have moved the conductor 7 far enough to prevent the arc restriking after the passage of the current through zero.

This device, therefore, is capable of interrupting currents barely great enough to melt the fuse and also capable of interrupting currents corresponding to severe short circuit. There may occur currents so heavy that the gas pressure developed in the first half-cycle will be great enough to burst the tube, but these conditions are beyond the current-range for which the device is intended.

In the operation of the apparatus illustrated in Fig. 2, when the fusible member 12 separates, the arc, which is established between it and the member 7, will jump to the washer 24 because the gas in the region between ferrule 2 and washer 24 is highly ionized and only a small arc voltage between member 7 and ferrule 2 is required to cause breakdown between ferrule 2 and washer 24. For small currents, the arc will therefore be transferred to the small passage where the rest of the operation is as explained in connection with Fig. 1.

Similarly, in the modification shown in Fig. 3, as soon as the conductor 7 has moved a little way, the impedance between the ferrule 2 and the free end of the conductor 22 is less than that between the ferrule 2 and the member 7. In both Figs. 2 and 3, when an arc has been formed, the flared end 19 is filled with ionized gas which extends to the mouth of the small passage 21 and the path over which the arc must be established to send current through the conductor 22 is of

small resistance because of this ionization. With heavy currents the conductor 22 melts almost instantly and the arc in passage 21 is shunted by the lower impedance arc in passage 18 and therefore is promptly extinguished.

It is thus seen that a gas blast circuit interrupter has been provided in which heavy short circuit currents are finally interrupted in a passage of large cross-section and in which smaller overloads are finally interrupted in a passage of small cross-section. This is desirable since it makes possible satisfactory interruption of the circuit over a wide range of currents which would not be possible if only a small passage were used since the large amount of gas evolved when the current is large would burst the tube, or if only a large passage were used since the walls would not be in intimate contact with the arc when it carries a small current so that insufficient gas would be evolved to extinguish the arc in such a large passage.

The passages 18 and 21 may be in boric acid or oil-soaked material or any other material which will preferably evolve an emanation under the influence of the arc of a character which tends to destroy the arc. Thus, boric acid evolves water vapor and fiber evolves hydrogen and carbon monoxide. Many other emanations possess a deionizing property and need not be separately mentioned.

Many other applications of this invention will be apparent to those skilled in the art to which it pertains and need not be specifically mentioned here. We do not intend the omission of such mention of them to act as a limitation. No limitation is intended except that required by the prior art or indicated in the claims.

We claim as our invention:

1. In a current-interrupting device, means for producing an arc and means for extinguishing said arc including a body responsive to the action of said arc to evolve an arc-destroying emanation, said body having two passages therethrough, said passages being defined by solid walls, a low resistance, all metallic conductor uniting adjacent ends of said passages and other conductors associated with the other ends of said passages for guiding the arc into the respective passages.

2. In a current-interrupting device, means for producing an arc, said means including a current-carrying member biased to move upon release and current-responsive means for releasing said biased member, and means for extinguishing said arc including a body responsive to the action of said arc to evolve an arc-destroying emanation, said body having a passage therethrough within which said member moves and another passage free from said member and affording a path for said arc and means for guiding the arc from the place of its production into said last-named passage.

3. In a current-interrupting device, means for producing an arc, said means including a current-carrying member biased to move upon release and current-responsive means for releasing said biased member, and means for extinguishing said arc including a body responsive to the action of said arc to evolve an arc-destroying emanation, said body having a passage therethrough within which said member moves and another passage free from said member and affording a path for said arc, the passage free from said member being of smaller cross section than the passage within which said member moves and

means for guiding the arc from the place of its production into said passage.

4. In a current-interrupting device, means for producing an arc, said means including a current-carrying member biased to move upon release and current-responsive means for releasing said biased member, and means for extinguishing said arc including a body responsive to the action of said arc to evolve an arc-destroying emanation, said body having a passage containing said member and partly filled thereby and a second passage of smaller cross-sectional area than the cross-sectional area of the space between said member and the walls of the passage containing it, said passages affording paths for the arc.

5. In a current-interrupting device, means for producing an arc, a body responsive to the action of said arc to evolve an arc-destroying emanation, said body having two passages therethrough, each of said passages opening into the space within which said arc originates, and an electrically conductive connection between the other openings of said passages, whereby a path for the arc is provided through either passage.

6. In a current-interrupting device, means for producing an arc, a body responsive to the action of an arc to evolve an arc-destroying emanation, said body having passages therethrough, means for directing the arc from the place of its production into said passages, said passages having different cross-sectional areas, whereby different arc extinguishing effects are produced in the several passages and one of said passages opening into the other of said passages at one end thereof.

7. In a current-interrupting device, an elongated body of material responsive to the action of an arc to evolve an arc-destroying emanation, said body having passages extending lengthwise therethrough, one of said passages having a flared mouth at one end, an electric terminal for the end of said body near said mouth, an electric terminal for the other end of said body, an elongated conductor extending from said flared mouth along the passage associated therewith and connected to each terminal, means responsive to current above a predetermined value for severing the connection to the first-named terminal, whereby an arc is formed in said flared mouth, means for moving said elongated conductor along said passage away from said mouth and means for shunting current from said arc into another of said passages.

8. In a current-interrupting device, an elongated body of material responsive to the action of an arc to evolve an arc-destroying emanation, said body having passages extending lengthwise therethrough, two of said passages having mouths near each other at one end of said body, a conductor extending through one of said passages, means for conveying current through said conductor, means for moving said conductor and thereby forming an arc adjacent said neighboring mouths and means for guiding current into the other of said passages.

9. In a current-interrupting device, an elongated body of material responsive to the action of an arc to evolve an arc-destroying emanation, said body having passages extending lengthwise therethrough, two of said passages having mouths near each other at one end of said body, conductors, one in each of said passages, extending lengthwise thereof, means for conveying current along one of said conductors, means for moving said conductor thereby forming an arc near said end of said body, the ionizing

influence of which extends to both said mouths, and means including the other of said conductors for guiding current into the other of said passages.

10. In a current-interrupting device, an elongated body of material responsive to the action of an arc to evolve an arc-destroying emanation, said body having passages extending lengthwise therethrough, said passages having mouths near each other at one end of said body, conductors, one in each of said passages, extending lengthwise thereof, means, including a terminal, for conveying current along one of said conductors, means for moving said conductor, thereby forming an arc and means, responsive to the arc, for establishing a connection from said terminal to the other of said conductors consisting at least in part of ionized gas.

11. In a current-interrupting device, an elongated body of material responsive to the action of an arc to evolve an arc-destroying emanation, said body having passages extending lengthwise therethrough, said passages having mouths near each other at one end of said body, conductors, one in each of said passages, extending lengthwise thereof, conductive terminals for said body, one connected to both said conductors, current-responsive means for connecting the other terminal to one of said conductors and severing said connection and thereby producing an arc when the current exceeds a predetermined value, the other of said conductors being destructible by current exceeding said predetermined value and means responsive to the arc for establishing a connection from said last-named terminal to said destructible conductor, said connection consisting at least in part of ionized gas.

12. In a current-interrupting device, an elongated body of material responsive to the action of an arc to evolve an arc-destroying emanation, said body having passages therethrough, conductors, one in each of said passages, current responsive means for producing an arc near one end of said body, said passages and conductors terminating within the space influenced by said arc, whereby said conductors then carry the arc current, one of said conductors being destructible by said current and the passage containing said destructible conductor being of smaller cross section than the other passage.

13. In a current-interrupting device, an elongated body of material responsive to the action of an arc to evolve an arc-destroying emanation, said body having passages therethrough, conductors, one in each of said passages, current-responsive means for producing an arc near one end of said body, said passages and conductors terminating within the space influenced by said arc, whereby said conductors then carry the arc current, means operable upon the operation of said arc-producing means for moving one of said conductors along its passage in the direction to lengthen the arc and the passage containing said movable conductor being of greater cross section than the other passage.

14. In a current interrupter, means for causing arcs over a plurality of paths, separate means for extinguishing said arcs to interrupt the current, and means for causing one of said separate means to finally interrupt the current when the current to be interrupted is large and another of said separate means to finally interrupt the current when the current to be interrupted is small.

15. In a current interrupter, a body having two passages of different cross sections therein, means

for establishing arcs in one or both of said passages in accordance with the arc current, means including the material of said body for extinguishing said arcs, the time rate of action of said means being dependent upon the current strength of the arc and the cross section of the passage, and each arc constituting substantially all of the impedance in parallel to the path through the other passage, whereby at small arc-currents the final interruption of current will occur in the passage of small cross section and at large arc-currents in the passage of large cross section.

16. In a current interrupter, a body having two passages therein with adjacent mouths, means for establishing arcs in said passages, said means including devices at said mouths responsive to difference of current strength to direct the final arc into one, or the other of said passages according to the strength of current in the arc.

17. In a current interrupter, means for providing a plurality of paths for the current, means for interrupting the current in any one of said paths, a fusible conductor and means acting in accordance with the time required for the current carried thereby to fuse said conductor for determining in which path final interruption of the current will occur.

18. In a circuit interrupter, means for extinguishing arcs carrying currents from a low to an intermediate value, means for extinguishing arcs carrying currents from an intermediate to a higher value, and means responsive to the magnitude of the current to be interrupted for selecting one of said arc extinguishing means to finally interrupt the current.

19. In a circuit interrupter, an arc extinguisher having ability to interrupt low current arcs, an arc extinguisher having ability to extinguish high current arcs, means electrically connecting said arc extinguishers in parallel in the circuit, and means responsive to the magnitude of the current for selecting said low current arc extinguisher to finally interrupt the circuit if the current is low and for selecting said high current arc extinguisher to finally interrupt the circuit if the current is high.

20. In a circuit interrupter, means providing a pair of arc paths electrically in parallel in the circuit, means for initially causing an arc along one of said paths, means for extinguishing said arc, means for initially causing a second arc along the other of said paths after said arc is caused along the first of said paths, means for extinguishing said second arc, said means for causing the second arc being responsive to the magnitude of the current for causing said second arc after the final extinction of the first arc if the current is low and for causing said second arc before the final extinction of the first arc if the current is high.

21. In a circuit interrupter, means of insulating material having a pair of passages therethrough of different cross-sectional area, means of conducting material extending through one of said passages for causing an arc therein in response to the flow of current through the circuit interrupter, a second means of conducting material extending through the second passage, said second means of conducting material being and remaining in shunt with the arc in the first passage for an interval of time and thereby causing

final extinction of the first arc prior to the causing of an arc in the second passage if the current to be interrupted is small, and said second means of conducting material quickly causing an arc if the current to be interrupted is large, and means for quickly extinguishing said arc in the second passage thereby finally interrupting the flow of current in shunt with the arc in the first passage prior to the final extinction of said arc in the first passage when the current to be interrupted is large.

22. In a circuit interrupter, means of insulating material having a large and a small passage therethrough, means of conducting material extending through said large passage, means for moving said means of conducting material for drawing an arc in said large passage, a second means of conducting material extending through said small passage, said second means of conducting material being and remaining in shunt with the arc in the large passage for a length of time sufficient to allow said means of conducting material to move and draw the arc to such a length that it will not restrike after current zero, if the current to be interrupted is small, and said second means of conducting material quickly causing an arc in said small passage if the current is large and said small passage causing the arc therein to be extinguished.

23. In a circuit interrupter, means movable apart for drawing an arc, means maintaining a conducting path in shunt with the arc for a length of time sufficient to allow said movable means to separate such a distance that the arc therebetween will not restrike after a current zero and said means maintaining the conducting path then causing an arc and finally interrupting the circuit if the current to be interrupted is small, and said means maintaining the conducting path in shunt with the arc being quickly interrupted if the current to be interrupted is large.

24. In a circuit interrupter, means having a plurality of arc passages therein of different sizes, conducting means for causing an arc in each of said passages, each of said passages having means therealong which when acted upon by an arc causes a blast of fluid through the arc to extinguish it, and means causing the circuit to be finally interrupted in the passage of larger size when the current to be interrupted is large and causing the circuit to be finally interrupted in the passage of smaller size when the current to be interrupted is small.

25. In a circuit interrupter, an arc extinguisher having ability to interrupt low current arcs and including means along the arc path which when acted upon by the arc causes a blast of fluid through the arc, an arc extinguisher having ability to extinguish high current arcs and including means along the arc path which when acted upon by the arc causes a blast of fluid through the arc, means electrically connecting said arc extinguishers in parallel in the circuit, and means responsive to the magnitude of the current for selecting said low current arc extinguisher to finally interrupt the circuit if the current is low and for selecting said high current arc extinguisher to finally interrupt the circuit if the current is high.

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