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CARTRIDGE-TYPE FUSE WITH EXPLOSION POTS

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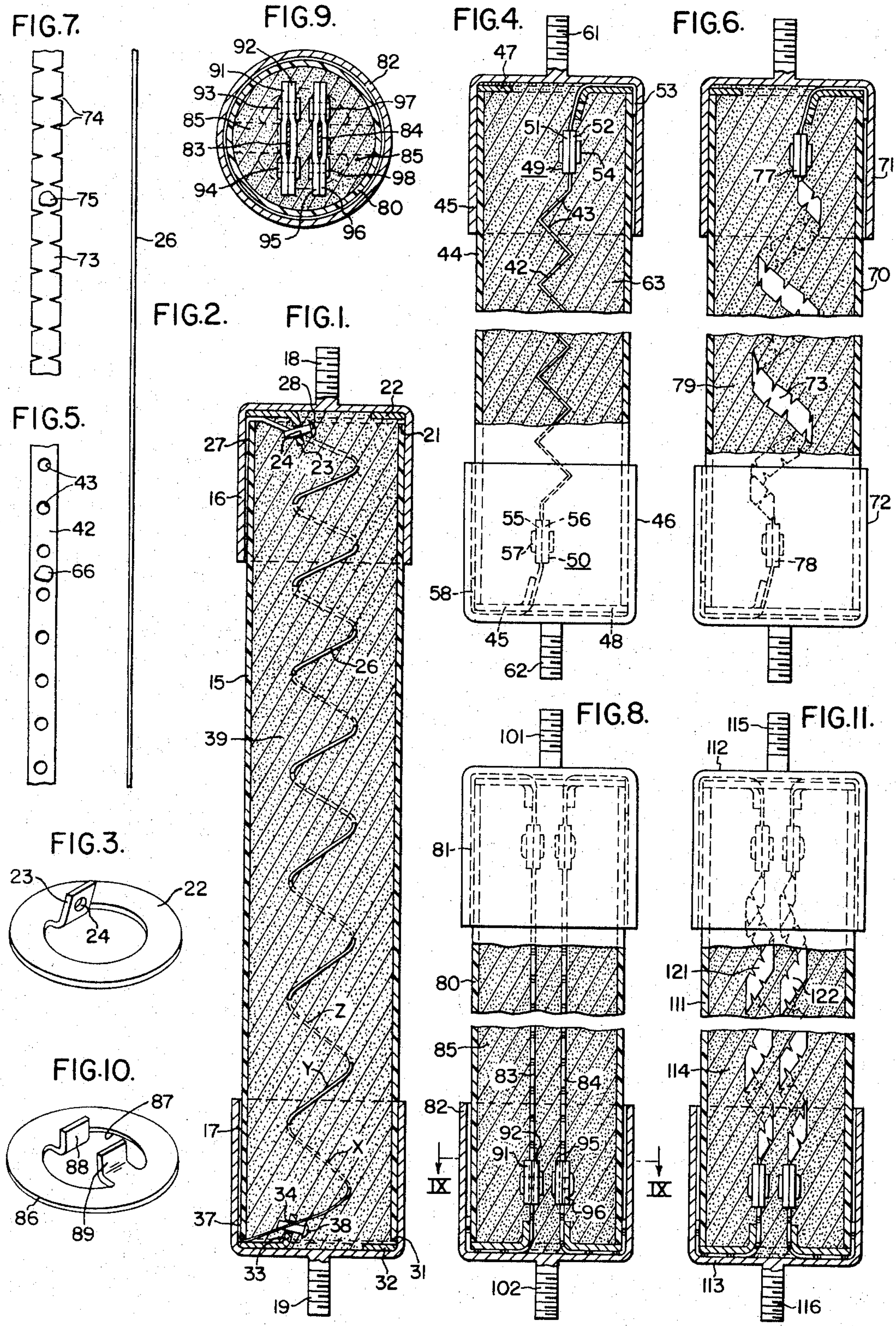

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CARTRIDGE-TYPE FUSE WITH EXPLOSION POTS

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This invention relates to improvements in fuses, and more particularly to a novel fuse construction which avoids any soldered or cemented fastenings, has self-protecting characteristics, and is compact and easily manufactured.

In summary, the fuse of my invention according to one embodiment thereof comprises a fusible element disposed in a fuse tube and having ferrules at each end thereof, the fusible element having physical characteristics whereby on large overcurrents the fuse element may burn through simultaneously at a number of points, causing a number of arcs to be formed, and on small overcurrents the fuse element may burn through at a first point forming an arc which thereafter burns back a distance until the current through the fuse falls to zero and the dielectric recovery strength of the fused sand (fulgurite) becomes adequate to prevent reignition. The ends of the fuse element are firmly clamped between a metallic plate-like member disposed within each ferrule between the end of the fuse tube and the adjacent surface of the ferrule. The fuse element also extends along the outside of the fuse tube and is clamped between the outer surface of the fuse tube and the inner adjacent wall of the ferrule.

The fuse element in several of the embodiments of my invention is prebent to distribute the elongation due to heating as a result of current or other factors at a number of points thereby preventing the fuse element from breaking.

The various embodiments of my invention employ a stepped wire as a fusible element, a folded perforated strip, a coiled notched strip extending between ferrules, two or more parallel notched strips, or two or more coiled notched strips extending in parallel paths between ferrules, depending upon the current capacity and the operating characteristics desired.

Accordingly, a primary object of my invention is to provide a new and improved fuse.

A further object is to provide a new and improved fuse having advantages over those now existing in the art.

Another object is to provide a new and improved fuse having an easily manufacturable format.

A further object is to provide a new and improved fuse which avoids any soldered, leaded or cemented fastenings.

Another object is to provide new and improved fuses having self-protecting characteristics.

These and other objects will become more clearly apparent after a study of the following specification, when read in connection with the accompanying drawings, in which:

FIGURE 1 is a cross-section through a fuse according to one embodiment of my invention, employing a stepped wire as the fusible element;

FIG. 2 is a detailed view of a portion of the fuse element of FIG. 1;

FIG. 3 is a detailed view of the metallic terminal ring or plate employed for holding the fuse element in position in the fuse tube;

FIG. 4 is a cross-section partially broken away of the fuse according to a second embodiment of my invention, employing a folded perforated strip as a fuse element;

FIG. 5 is a detailed view of the perforated strip of FIG. 4, showing also the alloy-forming solder which may be substantially centrally disposed along the fuse strip;

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FIG. 6 is a cross-section partially broken away of a fuse according to a third embodiment of my invention, which employs a notched strip in the form of a coil extending between ferrules;

FIG. 7 is a detailed view of the fuse element of FIG. 6 showing the alloy-forming solder which may be centrally disposed on the fuse element;

FIG. 8 is a view of my fuse according to a fourth embodiment thereof, showing two parallel notched strips extending between ferrules;

FIG. 9 is a cross-sectional view through the fuse of FIG. 8 along a transverse plane passing through the lines IX—IX thereof, and showing the terminating and supporting strips in more detail;

FIG. 10 is a detailed view of the end terminal ring of FIG. 8; and

FIG. 11 is a cross-sectional view of my fuse according to a fifth embodiment thereof.

Referring now to the drawings for a more detailed understanding of the invention, in which like reference numerals are used throughout to designate like parts, and more particularly to FIG. 1 thereof, the reference numeral **15** designates a fuse tube composed of a suitable insulating material, for example fiber, having at the ends thereof ferrules **16** and **17** respectively with threaded studs **18** and **19** respectively. These threaded studs are provided so that the fuse may be conveniently mounted in a hookstick operated load break device generally known as Westinghouse Electric Corporation type EFD, described and claimed in the copending application of J. J. Astleford and C. L. Wright for "Circuit Interrupter," Ser. No. 443,359, filed Mar. 29, 1965, and assigned to the assignee of the instant invention.

Disposed between the upper end **21** of the fuse tube **15** and the adjacent inner surface of the end of the ferrule **18** is a metallic terminal plate or metallic ring **22** shown in detail in FIG. 3. This ring is seen to have a tab or arm **23** extending therefrom toward the interior of the fuse tube, with a hole or bore **24** therein. The upper end of the fuse element **26** passes through the hole **24** and the end thereof is thereafter bent around the outside wall of the fuse tube, this end of the fuse element being designated **27**. A pin **28** is driven into the hole **24** after the fuse element **26** passes therethrough to fasten the fuse element in place.

It is seen that the fastening of the fuse element **26** in the terminal ring **22** requires no soldering, that making electrical connection between the end of the fuse element and the ferrule **16** requires no soldering, good electrical connection being provided by the terminal ring **22** and also by the end **27** of the fuse element which is forced into firm and close engagement with the inside surface of the ferrule as shown.

At the lower end of the fuse tube **15** there is disposed the aforementioned ferrule **17**, and between the lower end **31** of the fuse tube and the adjacent surface of the ferrule there is a terminal ring **32** having a tab **33** with a hole **34** therein through which passes the adjacent end **37** of the fuse element, the end **37** thereafter being folded back between the outer surface of the fuse tube and the inside wall of the ferrule. A pin **38** passes through hole **34** and fastens the wire in place therein.

The entire interior of the fuse tube **15** is filled with a suitable material such as fused sand **39**.

The aforementioned fuse element **26** is composed of a plurality of stepped wire sections of progressively increasing diameter. Element **26** is shown in somewhat idealized form in FIG. 2, but it will be understood that the fuse element is actually composed of discrete steps of wire sizes which may increase in steps of, for example, $\frac{1}{1,000}$ of an inch per step.

In the operation of the apparatus of FIGS. 1, 2 and 3, let it be assumed by way of example that a large fault current occurs, causing the fuse element 26 to burn through at, for example, a number of simultaneous points along the wire section of smaller diameter, for example points X–Y–Z. Arcs start to form which burn back very rapidly towards both ends of the element 26 and the arcs persist until the entire element 26 is consumed or the current is forced to zero. The rate of burn back is very rapid and is determined in part by the thermal capacity of the stepped wire 26.

Let it be assumed by way of illustration that the fuse element 26 of FIG. 1 is subjected to a low overload current which causes the fuse to heat until it melts at some point along the wire portion of smallest diameter, which may also be roughly in the neighborhood of point X. The element may be expected to melt at and near the center of the smallest wire, and the arc proceeds from there, burning back from the starting point. The arc burns back until such time as the current goes to zero and the dielectric recovery strength of the fused sand becomes adequate to prevent reignition.

It is observed that the fuse element 26 is in the form of a coil. Under current carrying conditions where the current is not large enough to cause the fuse element to melt, nevertheless the fuse element 26 expands and contracts when it is heated and cooled respectively as a result of variations in current and ambient conditions. The prebending of the fuse element 26 in the form of a coil distributes the elongation due to heating over the length of the wire and keeps the wire from breaking as a result of the expansion and contraction due to normal operation and ambient temperature effects.

It is observed that in FIG. 1, the portion of the fuse element 26 of largest cross section is in what appears to be the top of the fuse. Before the fuse tube 15 is filled with sand, it is desirable to have the portion of fuse element 26 of larger cross section at the upper end of the fuse, so that it may more readily support the portion of the fuse element below. After the fuse tube is filled with sand 39, it may be mounted in any position with either end up.

There has been provided then in FIG. 1 an embodiment of the invention which accomplishes all of the aforementioned objectives. The fuse element has self-protecting characteristics; no soldered or cemented fastenings are required at the ends of the fuse tube for the purpose of making electrical connection, and it is readily seen that the fuse is of an easily manufactured format.

Particular reference is made now to FIG. 4, where a second embodiment of the invention is shown. In FIG. 4, the fuse element 42 comprises a folded perforated strip of fusible material, shown in detail in FIG. 5. This strip 42 may be composed of silver having spaced perforations 43 therein. The fuse of FIG. 4 includes a fuse tube 44 composed of insulating material, ferrules 45 and 46 at the upper and lower ends thereof respectively, terminal rings 47 and 48 at the upper and lower ends thereof respectively, these rings being similar to those of FIG. 3, and "explosion pot" means near each end of the fuse element 42 and designated 49 and 50 respectively, these means 49 and 50 providing an "explosion pot effect." The means 49 includes two strips or plates 51 and 52 of insulating material which may be fiber or may be glass melamine or other suitable material, the two strips 51 and 52 being riveted together by rivets on each side of the fuse element, one of the rivets being shown at 54, the rivets of each pair of strips being similar to those shown in FIG. 9 hereinafter to be discussed in detail. The strips 51 and 52 have a length only slightly less than the inside diameter of the fuse tube 44 so that they position the end of the fuse element 42 substantially centrally within the fuse tube. The end 53 of the fuse element is seen to pass between the terminal plate or terminal ring 47 and the adjacent surface of ferrule 45 and to lap over the side of the fuse tube 44 so that excellent

electrical connection is provided between the fuse element 42, the terminal ring 47 composed of conductive material, and the ferrule 45 composed of conductive material.

Some discussion of the "explosion pot effect" may be had by reference to Patent No. 3,194,923, issued July 13, 1965 to F. L. Cameron et al. for "Current Limiting Fuse."

At the lower end of the fuse element 42 a similar arrangement is shown, the explosion pot effect means generally designated 50 having strips 55 and 56 of insulating material such as glass melamine, one rivet being shown at 57, the end 58 of the fuse element 42 passing through the opening in the terminal ring 48 and thence looping around and being pressed between the side of the fuse tube 44 and the inside wall of the ferrule 46. The ferrules 45 and 46 have threaded studs 61 and 62 respectively. Fused sand 63 substantially fills the interior of the fused tube 44. It is seen in FIG. 5 that there is a small layer, globule or daub of solder 66 on the fuse element 42 preferably near the center thereof. The solder is provided to give certain electrical characteristics to the fuse element.

In the operation of the apparatus of FIG. 4, assuming a very high overload current such as a fault current caused by short circuit, the fuse element 42 melts simultaneously at all or a number of the perforations 43 disposed along the length thereof. The fuse may melt along its entire length, or it may melt and disintegrate at one point starting an arc which burns back towards both ends of the fuse strip 42. The arc exists until the entire element 42 is consumed or the current through the fuse is reduced to zero. For a large overcurrent operation the explosion pot effect devices 49 and 50 may serve only as spacers and may not be used in extinguishing the arc and the current through the fuse.

Assume now by way of example that the fuse element 42 melts as a result of a small continuous overload which heats the strip to the melting point. Fuse element 42 will probably melt in the area thereof near the solder 66. As previously stated, the solder 66 is provided to change the melting characteristics of the fuse element 42. The solder has a lower melting temperature than the adjacent silver of the fuse element 42; when the solder melts the silver alloys into the tin and the result is a lower melting point for that portion of the fuse element 42 which has become alloyed as a result of the tin therein. This portion of the fuse element 42 melts and eventually the circuit is broken, forming an arc which burns back towards both ends of the fuse element 42. The burn back proceeds from the starting point towards the devices 49 and 50. Assuming that the arc has not been extinguished before the arc reaches devices 49 and 50, when the arc begins to form between the two strips 51 and 52, or between the two strips 55 and 56, it creates a high localized pressure which tends to extinguish the arc. As a result of the high pressure generated an expulsion effect is provided; gases given off by the glass melamine tend to deionize that spot or that region, with the result that the arc is extinguished in the region of devices 49 and 50 and the current flow through the fuse is extinguished.

The bending of the fuse element 42 adds to the fatigue strength thereof and the prebending distributes the elongation due to heating of the fuse at a number of points during normal variations in current and ambient conditions and tends to keep the fuse from breaking.

Particular reference is made now to FIG. 6, where a third embodiment of the invention is shown. Fuse tube 70 has ferrules 71 and 72 and has a fuse element 73 a notched strip composed of silver or other suitable fusible material, a portion of which is shown in detail in FIG. 7. The fuse element 73 has notches 74 at spaced intervals along the length thereof and solder daub 75. In FIG. 6, to which particular attention is again directed, it is seen that the fuse element 73 is supported at both ends thereof in a manner similar to fuse element 42 of FIG. 4, so that the termination of the ends of element 73 need not be described in detail.

The fuse element 73 is shown in FIG. 6 as being in the form of a coil. The coil of FIG. 6 may be easily provided by winding the fuse strip on a mandrel and thereafter removing the mandrel. Generally speaking, the coil 73 of FIG. 6 is not as strong as the bent strip 42 of FIG. 4. The coil however provides the same effect as bending, that is, it enables the fuse element to expand and contract without breaking, and also provides a longer strip. Fuse element 73 is supported by explosion pot devices 77 and 78 at the ends thereof, and fuse tube 70 is filled with fused sand 79.

The operation of the fuse of FIG. 6 is generally similar to that of FIG. 4. On large fault currents, the fuse element 73 melts simultaneously at many places corresponding to the notches therein. The arcs burn back rapidly towards both ends of the fuse element until the arcs are extinguished. On low fault currents, the fuse element 73 burns through at one point probably near the solder 75 because of the alloying effect; an arc starts which progresses towards both ends of the fuse element 73, and if the arc reaches either of the devices 77 or 78 it creates a high localized pressure which tends to extinguish the arc. As a result of the high pressure an expulsion effect is provided and gases given off by the glass melamine strips tends to deionize those spots or those regions, extinguishing the arc.

The fuse tube 70 of FIG. 6 may be, if desired, fluid-tight so that the fuse may be mounted inside a bushing in the tank of a transformer or other electrical device, with part of the fuse submerged under the oil.

Particular reference is made now to FIG. 8, which shows a fourth embodiment of the invention. In FIG. 8, fuse tube 80 has ferrules 81 and 82 at the ends thereof, and the fusible element comprises a pair of parallel strips or parallel notched elements 83 and 84. The space within the fuse tube is filled with fused sand 85.

Particular reference is made now to FIG. 10, where a detailed view of the terminal rings employed in the embodiment of FIG. 8 is shown. Terminal ring 86 has a central opening 87 and two oppositely disposed tabs 88 and 89 extending therefrom. As will be seen more fully hereinafter, the fusible elements 83 and 84 are bent over these tabs, pass around the end of the terminal ring and thence are bent back between the outside of the fuse tube 80 and the inner wall of the ferrules 81 and 82. The fuse elements 83 and 84 each pass through a pair of strips as shown in FIG. 9, where fusible element 83 is seen passing through strips 91 and 92 held together by rivets 93 and 94, and fusible element 84 is seen passing through strips 95 and 96 held together by rivets 97 and 98. There is provided then, in each end of each fuse element, means forming a dual explosion pot device similar to that previously described.

Ferrules 81 and 82 have threaded studs 101 and 102 respectively. It is seen that the upper portion of the fuse of FIG. 8 is supported, spaced and anchored in a manner similar to the lower portion thereof and need not be described in detail.

In the operation of the fuse of FIG. 8, large overload currents such as those caused by a fault or short circuit may cause both fuse elements 83 and 84 to be burned through at substantially the same time forming arcs which burn back towards the ends thereof until they are extinguished. On continuous small overloads which ultimately result in the melting of one of the elements 83 and 84, the current is diverted to the remaining element comprising a substantial overload for the remaining element which thereupon melts and an arc is formed which burns back towards the ends of the element, the arc being ultimately extinguished, or if the current has not been extinguished by the time the arc reaches the explosion pot devices, then it is effectively snuffed out in these areas.

The configuration of FIG. 8 may be employed where larger current carrying capacity is needed than can be obtained with a single notched or perforated strip.

Elements 83 and 84 may have solder thereon to provide the alloying effect previously described and to reduce the melting temperature in that area.

Particular reference is made now to FIG. 11, where a fifth embodiment of the fuse according to my invention is shown. FIG. 11 includes a fuse tube 111 with ferrules 112 and 113, the fuse tube being filled with fused sand 114, ferrules 112 and 113 having threaded studs 115 and 116 respectively. The fuse elements 121 and 122 are seen to be notched strip, in the form of coils. The fuse of FIG. 11 then provides a longer fuse element and a correspondingly higher voltage fuse when compared to that of FIG. 8, and in addition the coil configuration of the fuse elements provides for expansion and contraction of the elements in response to temperature changes which are not sufficiently great to cause the fuse elements to melt.

In all embodiments, the tabs of the terminal rings at the top of the fuse also serve to insure that arcing takes place in the fused sand. The sand may become so packed that a small unfilled space tends to be formed at the upper end of the fuse; the high current carrying tab passes through this space.

There has been provided then fuse apparatus well suited to accomplish the aforedescribed objects of the invention.

Whereas I have shown and described my invention with respect to some embodiments thereof which give satisfactory results, it should be understood that changes may be made and equivalents substituted without departing from the spirit and scope of the invention.

I claim as my invention:

1. A self-protecting fuse comprising a fuse tube, first and second ferrules at the ends of the fuse tube respectively, a fuse element disposed within the fuse tube, first and second terminal rings disposed between the ends of the fuse tube and adjacent the first and second ferrules respectively, the terminal rings being composed of conductive material and making electrical contact with the ferrules respectively, each of the terminal rings having a tab extending therefrom with a bore therein, the adjacent end of the fuse element passing through the bore in the tab and thence passing around the outside of the adjacent end of the fuse tube and being forced against the outer wall of the fuse tube and the inner wall of the ferrule, a pin disposed within the bore of each tab and fastening the fuse element in place therein, a granular arc-extinguishing material filling the space within the fuse tube, both the tabs being of sufficient length whereby, while the fuse is mounted with its longitudinal axis in a vertical position, the upper tab extends beneath the surface of the granular arc-extinguishing material and the bore thereof remains within the granular arc-extinguishing material, the fuse element upon melting due to a large overload current or a sustained small overload current starting an arc which burns back towards the ends of the fuse tube, the tab extending beneath the surface of the granular arc-extinguishing material preventing the arc from reaching the adjacent ferrule and damaging said last-named ferrule.

2. A fuse comprising, in combination, a fuse tube, first and second ferrules at the ends thereof, a fuse element within the fuse tube having one end electrically connected to one ferrule and the other end thereof electrically connected to the other ferrule, and first and second explosion pot devices secured to the fuse element near the ends thereof respectively substantially within the confines of the ferrules, each of the explosion pot devices including a pair of strips of gas evolving material secured to the fuse element, the strips extending radially substantially all the way across the interior of the fuse tube and posi-

tioning the fuse element substantially axially of the fuse tube thereby preventing the fuse element when heated to operating temperature from moving away from the axial center of the fuse tube.

3. A self-protected fuse comprising a fuse tube, first and second ferrules at the ends of the fuse tube respectively, a fuse element disposed within the fuse tube, first and second terminal rings disposed between the ends of the fuse tube and adjacent the first and second ferrules respectively, the terminal rings being composed of conductive material and making electrical contact with the ferrules respectively, each of the terminal rings having a tab extending therefrom toward the axial center of the fuse tube, the adjacent end of the fuse element passing around the tab and thence passing along the outside of the adjacent end of the fuse tube and being forced against the outer wall of the fuse tube and the inner wall of the ferrule, means disposed on the fuse element substantially at the axial center thereof and having a lower melting temperature than the melting temperature of the fuse element itself, said last named means when melted as a result of being raised to its melting temperature forming an alloy with the material of the portion of the fuse element adjacent thereto and lowering the melting point of said portion of the fuse element whereby the fuse element is separated in two at said portion thereof by a small excess current flowing therethrough over an extended period of time and an arc starts to form, said arc burning back towards the ends of the fuse element, two explosion pots disposed near the two ends of the fuse element respectively within the confines of the ferrules respectively, each of the explosion pots including a pair of strips of insulating material capable of evolving an arc extinguishing gas disposed closely adjacent the fuse element on both sides thereof, means clamping each pair of strips of insulating material to the fuse element, each explosion pot, when the portion of the fuse element therein begins to be consumed by the arc, emitting gas and creating a high gas pressure within the area confined by the strips of insulating material, said last-named gas deionizing the adjacent area and tending to extinguish the arc, and a granular arc extinguishing material substantially filling the space within the fuse tube not occupied by the fuse element and the explosion pots, both of the tabs being of sufficient length whereby, while the fuse is mounted with its longitudinal axis in a vertical position, the upper tab extends beneath the surface of the granular arc extinguishing material and the lower end thereof remains within the granular arc extinguishing material, the tab extending beneath the surface of the granular arc extinguishing material preventing an arc which burns back past the adjacent explosion pot from reaching the adjacent ferrule and damaging said last-named ferrule.

4. A self-protecting fuse comprising a fuse tube, first and second ferrules at the ends of the fuse tube respectively, a fuse element disposed within the fuse tube, first and second terminal rings disposed between the ends of the fuse tube and adjacent the first and second ferrules respectively, the terminal rings being composed of conductive material and making electrical contact with the ferrules respectively, each of the terminal rings having a tab extending therefrom toward the axial center of the fuse tube, the adjacent end of the fuse element passing around the tab and thence passing around the outside of the adjacent end of the fuse tube and being forced against the outer wall of the fuse tube and the inner wall of the ferrule, two explosion pots disposed near the two ends of the fuse element respectively within the confines of the ferrules respectively, each of the explosion pots including a pair of strips of insulating material capable of evolving an arc extinguishing gas disposed closely adjacent the fuse element on both sides thereof, means clamping each pair of strips of insulating material to the fuse element, granular arc extinguishing material substantially filling the space within the fuse tube not occupied by the fuse element and the explosion pots, each explosion pot, when an arc created by interruption of the fuse element burns back to the explosion pot, emitting gas and creating a high gas pressure within the confines of the ferrule, said last-named gas deionizing the adjacent area and tending to extinguish the arc, both of said tabs being of sufficient length whereby, while the fuse is mounted with its longitudinal axis in a vertical position, the upper tab extends beneath the surface of the granular arc extinguishing material, an arc burning back toward the end of the fuse tube and reaching the tab being transferred to the tab thereby preventing the arc from reaching the adjacent ferrule and damaging said last-named ferrule.

5. A fuse according to claim **4** including means on the fuse eleent at substantially the axial center thereof for causing the fuse element to burn in two adjacent said means in response to a small overcurrent of long duration.

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