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Cameron

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[54] **CURRENT LIMITING FUSE**

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[52] **U.S. Cl.** **337/233,** 337/159, 337/295
[51] **Int. Cl.** **H01h 85/16**
[58] **Field of Search** 337/159, 161, 228, 337/229, 231, 233, 293, 295, 244

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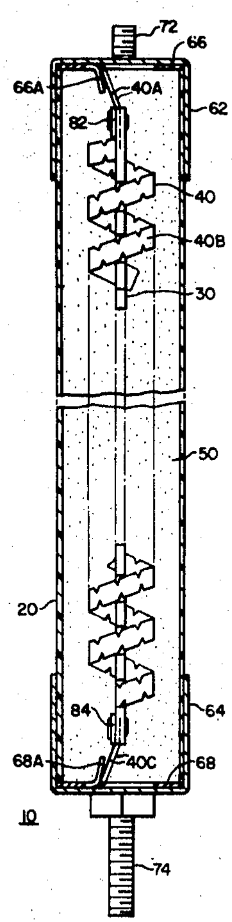
[57] **ABSTRACT**

A current limiting fuse structure comprising a generally tubular, electrically insulating casing having terminal means disposed adjacent to the opposite ends thereof. One or more fusible elements is connected between the terminal means. An electrically insulating support member is disposed in the casing of the fuse structure with the ends axially spaced from the respective terminal means. The intermediate portion only of each fusible element is disposed on the associated insulating support member and the end portions extend axially between the ends of the associated support member and the adjacent respective terminal means.

6 Claims, 6 Drawing Figures



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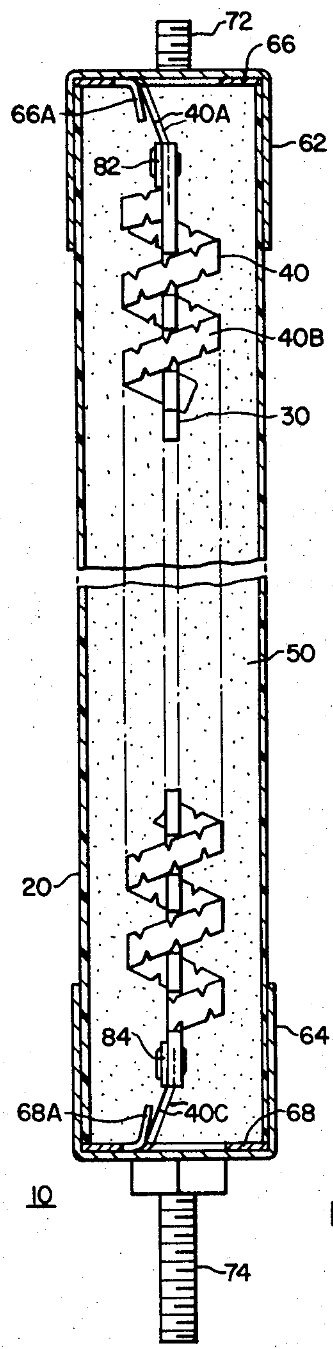

FIG. I.

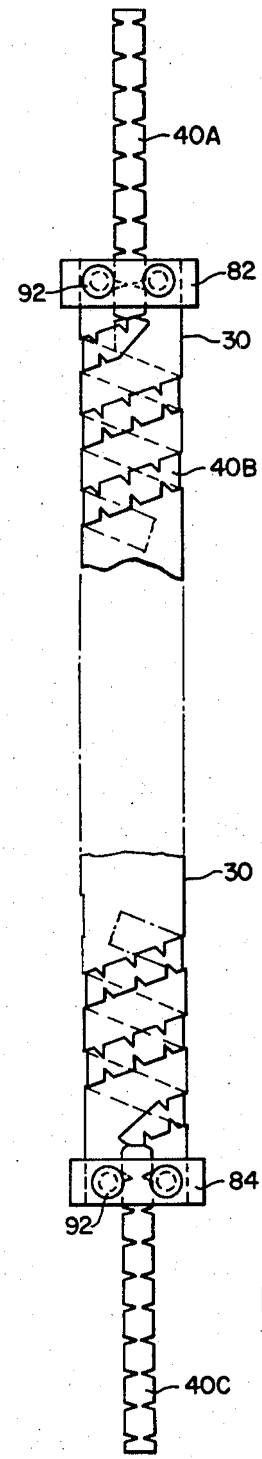

FIG. 2.

WITNESSES

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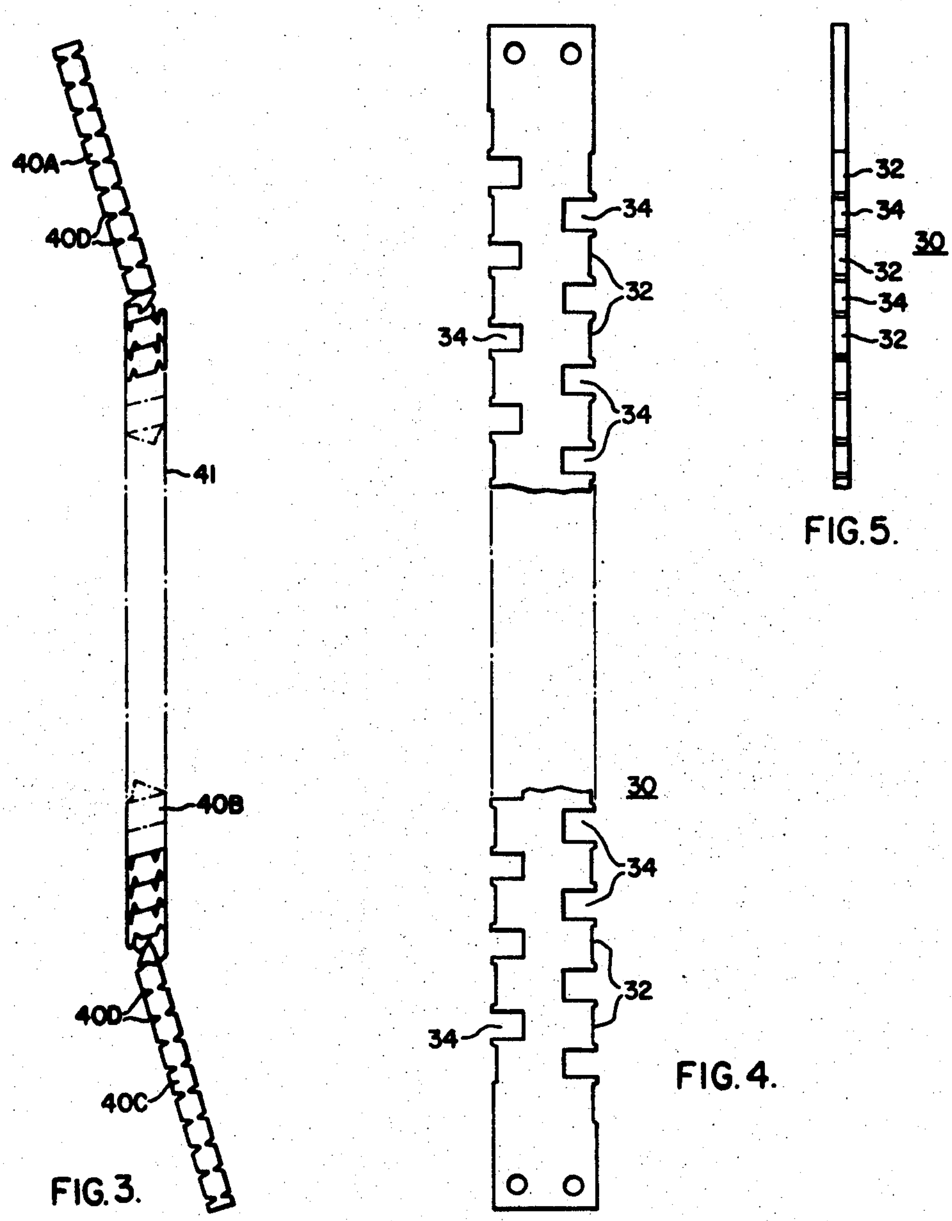
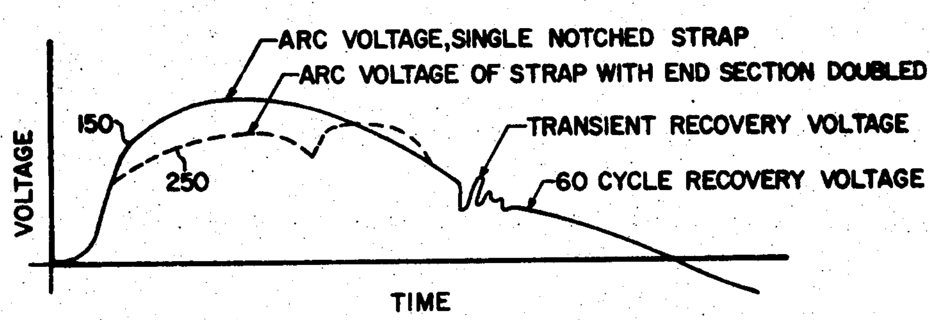


FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.



CURRENT LIMITING FUSE

BACKGROUND OF THE INVENTION

In the operation of certain types of current limiting fuses, such as those of the back-up type which are adapted to cooperate with an associated circuit interrupter having a relatively lower interrupting rating or capability, such a fuse may be required to have a predetermined minimum interrupting current rating along with a relatively high maximum interrupting current rating. In the construction of fuses of the type described, the cross-sectional size of the fusible elements employed is relatively small and each fusible element normally includes portions of reduced cross-section to provide the desired current limiting action. In order to support each fusible element, an electrically insulating support member may be provided which extends axially between the associated end terminals or ferrules such as disclosed in U.S. Pat. No. 3,294,936 or in copending application Ser. No. 872,895, filed Oct. 31, 1969, now U.S. Pat. No. 3,569,891, which is assigned to the same assignee as the present application. It has been found in a fuse structure of the type described, a problem arises in certain relatively high voltage applications, such as 15 KV and above, if the support member on which each fusible element is mounted is formed from a gas evolving material to assist in arc extinction since during certain operating conditions, an axially extending, continuous current leakage path may result along such a support member. One construction proposed to help overcome this problem is to provide recesses or depressions at the outer periphery of the support member intermediate the locations at which the associated fusible elements are supported, such as disclosed in U.S. Pat. No. 3,437,971. Another problem which arises in fuses of the type described is the possible damage to the end caps of the fuse if arcing during the operation of the fuse extends axially back to a location which is at or adjacent to such end caps. It is therefore desirable to provide an improved fuse structure of the type described which assists in overcoming the above problems as well as providing other advantages.

SUMMARY OF THE INVENTION

In accordance with the invention, a current limiting fuse structure comprises a generally tubular, electrically insulating casing or housing having terminal means mounted on said casing adjacent to each of the opposite ends of the casing. One or more fusible elements is disposed in the casing and electrically connected between the associated terminal means. In order to assist in supporting each fusible element in a predetermined shape or disposition, an electrically insulating, axially extending support member is disposed in said casing with the ends of said support member being disposed adjacent to and axially spaced from the respective terminal means. The intermediate portion only of each fusible element is disposed on the associated support member and the end portions of each fusible element extend axially between the respective ends of the associated support member and the adjacent terminal means. To aid in arc extinction, the support member may be formed from a material which is adapted to evolve gas in the presence of an arc and a quantity of pulverulent arc quenching material such as quartz or silica sand may be disposed in the casing in contact with or to embed each associated fusible element.

Where desired, each fusible element provided may be formed from an electrically conducting fusible material of the flat, ribbon type having periodically spaced restricted portions along its length with the intermediate portion of the fusible element helically disposed on the associated support member. In the latter embodiment of the invention, each fusible element may be of an overall predetermined length with each of the end portions being formed by bending or doubling a predetermined length of each of the respective ends of the fusible material back on itself to increase the effective cross-sectional area of each of said end portions to be relatively greater than that of the associated intermediate portion of the fusible element. The corresponding adjacent restricted portions of the fusible material which forms part of the bent back or doubled end portions are preferably substantially aligned with each other.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be had to the preferred embodiment, exemplary of the invention shown in the accompanying drawings in which:

FIG. 1 is a view, partly in elevation and partly in section, of a current limiting fuse structure embodying the invention;

FIG. 2 is an elevational view of a subassembly which forms part of the fuse structure shown in FIG. 1 and which includes a fusible element and an associated electrically insulating support member on which only a portion of the fusible element is disposed;

FIG. 3 is an enlarged elevational view, illustrating the manner in which the fusible element which forms part of the fuse structure shown in FIG. 1 is formed;

FIG. 4 is an elevational view of an electrically insulating support member which forms part of the fuse structure shown in FIG. 1, and on which a portion of the fusible element of the overall fuse structure is disposed;

FIG. 5 is a partial elevational view of the electrically insulating support member shown in FIG. 4; and

FIG. 6 is a graphical representation, illustrating the operation of the fuse structure shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and FIG. 1 in particular, there is illustrated a current limiting fuse structure **10** which is particularly adapted for high voltage applications, such as 15 KV and above, and which embodies the principal features of the invention. As illustrated, the fuse structure **10** includes a generally tubular casing or housing **20** which is formed from a suitable electrically insulating material which has sufficient structural strength to withstand the thermal conditions and internal pressures which may result during the operation of the fuse structure **10**, such as a glass-reinforced epoxy resin material. In order to close off the opposite ends of the casing **20** and to provide means for making electrical connections to the fuse structure **10** adjacent to the ends thereof, the terminal end caps or electrically conducting ferrules **62** and **64** are secured to the opposite ends of the casing **20** by suitable means, such as the magnetic forming method which is described in detail in U.S. Pat. No. 3,333,336 which issued Aug. 1, 1967 to F. L. Cameron and W. C. Good and which is assigned to the same assignee as the present application. Where desired, the axially projecting electrically conducting studs 72 and 74 may be mounted on or integrally formed with the end caps 62 and 64, respectively, in order to permit the mounting of the fuse structure 10 in particular types of supporting structures. As illustrated, the fuse structure 10 also includes the internal terminal member 66 and 68 which are generally disposed between the opposite ends of the casing 20 and the respective end caps 62 and 64. Each of the terminal members 66 and 68 is formed from a suitable electrically conducting material, such as copper or a copper alloy, and includes a central opening with a tab portion formed integrally at one side of the central opening which projects axially inwardly at one end of the associated casing, as indicated at 66A for the terminal 66 and as indicated at 68A for the terminal member 68 as shown in FIG. 1.

In order to assist in supporting the fusible element 40 in a desired assembled configuration, which will be described in detail hereinafter, to assist in properly positioning the fusible element 40 inside the casing 20 at a location which is laterally or radially spaced from the inner bore of the casing 20 and for other purposes where desired, the axially extending electrically insulating support member 30 is disposed inside the casing 20 with the opposite ends of the support member 30 being disposed adjacent to and spaced axially from the respective terminal members 66 and 68, as best shown in FIGS. 1. As illustrated in FIGS. 4 and 5, the elongated support member 30 is generally rectangular in cross-section. The support member 30 is preferably formed or molded from an electrically insualting material which has sufficient structural strength to withstand the thermal conditions and pressures which may result during an interrupting operation of the fuse structure 10 and may be a glass-reinforced thermosetting resin, such as a polyester resin. The material from which the support member 30 is formed may also include a filler material such as aluminum trihydrate to provide the support member 30 with desirable antitracking characteristics.

In order to assist in arc interruption or extinction during the operation of the fuse structure 10, the material selected for the support member 30 may also be of the gas evolving type such as a glass-reinforced polyester material. Where the support member 30 is formed from a material which is also gas evolving, the support member 30 may include a plurality of axially spaced relatively deeper recesses, as indicated at 34 in FIG. 4, at each of the opposite sides of the support member 30, in order to prevent the formation of an axially extending electrically conducting leakage path along the different surfaces of the support member 30 during an interrupting operation of the fuse structure 10. In order to better support and retain the different portions of the fusible element 40 in the desired assembled positions, as indicated in FIG. 1, the support member 30 may also include a plurality of axially spaced relatively shallow recesses or cuts as indicated at 32 in FIG. 4 at each of the opposite sides of the support member 30 which are generally disposed intermediate the successive respective deeper recesses 34. It is to be noted that the plurality of recesses 32 and 34 provided at the opposite sides of the support member 30 may be axially offset with respect to each other in order to achieve or result in a helical disposition or configuration of the intermediate portion 40B of the fusible element 40 when the fusible element 40 is assembled on the support member 30.

In general, the fuse structure 10 includes one or more fusible elements 40 which are electrically connected and extend axially between the terminal end caps 62 and 64 or between the terminal members 66 and 68, as illustrated. As shown, the fuse structure 10 includes a single fusible element 40 which is electrically connected between the terminal members 66 and 68. More specifically, as best shown in FIGS. 2 and 3, the fusible element 40 comprises the first and second end portions 40A and 40C and an intermediate portion 40B. As shown in FIG. 3, the fusible element 40 may be formed from a predetermined length of electrically conducting, fusible material, such as silver, of the flat, ribbon type and include a plurality of axially spaced points of reduced cross-sectional area as indicated at 40D which may be formed by V-notching the ribbon material from which the fusible element 40 is formed on both sides at spaced points along its length which result in a series of restricted areas which fuse initially during an interrupting operation of the fuse structure 10 to provide a series of spaced arcs, the sum of the voltages across said arcs resulting in a relatively high total arc voltage during the operation of the fuse structure 10 to limit the overload current which flows to a value less than that which would otherwise result. The intermediate portion 40B of the fusible element 40 may be formed by tightly winding the intermediate portion of the fusible material from which the fusible element is formed on an associated separate mandrel 41 which is generally circular in cross-section in a helical fashion, as indicated in FIG. 3. Where the fuse structure 10 is to be applied as a "backup" fuse as previously described, the fusible element 40 is preferably formed without any low melting material disposed thereon to permit the fusible element 40 to withstand certain relatively lower overload currents without damage.

After the fusible element 40 is formed as shown in FIG. 3, the intermediate portion 40B may be helically wound or assembled on the associated support member 30, as shown in FIGS. 1 and 2, with the turns of the fusible element 40 being retained in the assembled positions by the notches or recesses 32 provided at the opposite sides of the support member 30 as previously described. In order to secure the intermediate portion 40B of the fusible element 40 to the support member 30 after the intermediate portion 40B is assembled on the support member 30 as shown in FIG. 2, a pair of clamping plates 82 and 84 is assembled at the opposite ends of the support member 30 with the fusible element 40 passing between the respective clamping plates 82 and 84 and the support member 30. In order to fasten the clamping plates 82 and 84 to the support member 30 on the opposite sides of the fusible element 40, suitable means, such as a pair of eyelets 92, may be disposed to pass through substantially aligned openings provided in the respective clamping plates 82 and 84 and the support member 30.

In order to provide the necessary electrical connections between the opposite ends of the fusible element 40 and the associated terminal members 66 and 68, the ends of the fusible element 40 may be assembled to pass over the tab portions 66A and 68A prior to the assembly of the associated end caps 62 and 64 over the ends of the casing **20** as shown in FIG. **1** and then clamped or secured between the end caps **62** and **64** and the respective terminal members **66** and **68.**

In order to additionally aid in arc interruption during the operation of the fuse structure **10** and to provide the current limiting action which is necessary in a fuse structure in the type described, the space between the casing **20** and the fusible element **40** and between the casing **20** and the supporting member **30** is substantially filled with a finely divided pulverulent or granular arc-quenching material, such as silica sand or quartz sand, in which the fusible element **40** is effectively embedded. It is to be noted that after the casing **20** is substantially filled with the arc-quenching material which is indicated at **50** in FIG. **1**, the arc-quenching material **50** may then be compacted by any suitable means, such as vibration or other known methods.

It is to be noted that only the intermediate portion **40B** of the fusible element **40** is disposed on the support member **30** and that the associated end portions **40A** and **40C** each extend axially from one end of the support member **30** to the associated terminal members **66A** and **68A**, respectively, as shown in FIG. **1**, with a predetermined axial spacing between each end of the support member **30** and the adjacent terminal member as previously described. Where desired, the effective cross-sectional area of each of the end portions **40A** and **40C** of the fusible element **40** may be increased compared with that of the intermediate portion **40B**. This may be accomplished, as shown in FIG. **3**, in which the end portions **40A** and **40C** are formed by bending each of the respective ends of the predetermined length of fusible material from which the fusible element **40** is formed back on itself a predetermined distance or length with the corresponding restricted portions of the fusible material, as indicated at **40D** in FIG. **3**, which is bent back on itself being substantially aligned, as shown in FIG. **3**. In other words, by the method of construction just described, the cross-sectional area of each of the end portions **40A** and **40C** is substantially twice as great as the cross-sectional area of the intermediate portion **40B** of the fusible element **40** by bending or doubling the ends of the fusible material from which the fusible element **40** is formed back on itself, as just described. Where the end portions **40A** and **40C** of the suitable element **40** are bent back or doubled back as previously described, the corresponding restricted portions of the fusible material which makes up said end portions are preferably substantially aligned in order that said end portions form a series of arc voltages which assist in limiting the overload current which results during an interrupting operation of the fuse structure **10**. Where the fusible element **40** is constructed as just described, a stepped configuration of the fusible element **40** results which has certain important advantages which will be described hereinafter.

The operation of the overall fuse structure **10** will be considered first on the assumption that the cross-sectional area of each of the end portions **40A** and **40C** is relatively greater than that of the intermediate portion **40B** as just described. Based upon the latter assumption, when an abnormal or overload current starts to flow through the fusible element **40** of the fuse structure **10**, the intermediate portion **40B** having a relatively smaller cross-sectional area, will begin to melt initially and a series of arc voltages will develop between the particles or drops of vaporized or melted fusible material from which the fusible element **40** is formed. As the melting of the intermediate portion or section **40B** proceeds, the total arc voltage which develops in the intermediate portion **40B** will increase quickly to a peak value prior to the melting of the associated end portions **40A** and **40C**. As the size of the arc current which flows due to the melting of the intermediate portion **40B** increases, the peak arc voltage which develops will tend to partially collapse due to the increased size of the arc current which develops during the melting of the intermediate portion **40B**. When the melting of the intermediate portion **40B** is substantially completed, the end portions **40A** and **40C**, each of which has a relatively larger cross-sectional area than that of the intermediate portion **40B**, will then begin to melt or burn back and to effectively increase the arc voltage which is produced by the sequential melting of the different portions of the fusible element **40**. In other words, the stepped construction of the fusible element **40** will not result in a single arc voltage peak during the operation of the fuse structure **10**, but will tend to sustain the arc voltage for a sufficient period of time which results in more than one peak arc voltage, as shown by the curve **250** in FIG. **6**, to insure the interruption of the arc current which results during the operation of the fuse structure **10**. It is important to note that the magnitude of the two peak voltages as indicated by the curve **250** is less than the magnitude of the single peak voltage as indicated by the curve **150** in FIG. **6** which would result if a stepped construction were not provided. The stepped construction of the fusible element **40** therefore permits a relatively shorter longitudinal or axial dimension of the overall fuse structure **10** than if fusible elements were employed having only a single cross-sectional area (for other than the restricted portions) and therefore results in a more compact construction of the fuse structure **10** for a particular voltage rating.

It is to be noted that during the operation of the fuse structure **10** as just described, the arc-quenching material **50** which is disposed in the casing **20** will aid or assist in arc interruption by absorbing the thermal energy of the arc currents which develop during the operation of the fuse structure **10** and form a fulgurite with the vaporized material of the fusible element **40** as is well known in the fuse art. In addition, where the support member **30** is formed from a gas evolving material, the gases evolved during an interrupting operation from the support member **30** when subjected or exposed to arcs will also assist in the interruption of the overload currents which the fuse structure **10** is intended to interrupt. It is important to note that in the operation of the fuse structure **10** as just described, the predetermined axial spacing or gap between each end of the support member **30** and the respective terminal members **66** and **68** cooperates with the recesses **34** where provided on the support member **30** to insure that an axially extending electrically conducting leakage path does not occur during the operation of the fuse structure **10** due to excessive gases being evolved from the support member **30**. It is also important to note that where the cross-sectional area of each of the end portions **40A** and **40C** is relatively greater than that of the intermediate portion **40B**, of each fusible element **40**, the end portions **40A** and **40C** to a degree function as extensions of the terminal member **66** and **68**, respectively in that these portions burn back more slowly during an interrupting operation of the fuse structure 10 and help prevent possible burning of the terminals 66 and 68 and the associated end caps 62 and 64, respectively which might otherwise result during an interrupting operation of the fuse structure 10.

In the operation of the fuse structure 10 if the end portions 40A and 40C were not bent back to increase the relative cross-sectional area of each of said end portions compared with that of the intermediate portion 40B, the operation of such a fuse structure would be similar to that of the fuse structure 10 as previously explained except that only a single arc voltage peak would result during the operation of the fuse structure, as shown by the curve 150 in FIG. 6, which would require a larger longitudinal dimension of the overall fuse structure for a particular voltage rating. It is also to be noted that regardless whether the end portions 40A and 40C of the fusible element 40 are bent back or doubled back to increase the relative cross-sectional area of said end portions, the helical configuration of the intermediate portion 40B of the fusible element 40 permits a predetermined length of the overall fusible element 40 to be disposed in a relatively smaller axial dimension than if the fusible element 40 were disposed to simply extend axially between the associated end terminals of the fuse structure 10. In other words, the longitudinal dimension of the overall fuse structure 10 is reduced for a given voltage rating by the helical disposition of the intermediate portion 40B of the fusible element 40 on the associated support member 30.

It is to be understood that the teachings of the invention may be applied to a current limiting fuse structure in which the cross-sectional shape of the support member provided may be generally star-shaped or other shape rather than rectangular as disclosed. It is to be noted that the clamping members 82 and 84 which secure the intermediate portion 40B of the fusible element 40 to the support member 30 may also be formed from a suitable electrically insulating gas evolving material when subjected to arcs which may be the same material as that disclosed for the support member 30 previously.

The current limiting fuse structure embodying the teachings of this invention has several advantages. For example, in a current limiting fuse structure including an electrically insulating gas evolving support member as disclosed, the predetermined spacing or gap between each end of the support member and the associated respective terminal members assists in preventing the formation of an axially extending, electrically conductive leakage path between the terminal members at the opposite ends of the overall fuse structure. In addition, the disclosed fuse structure is uniquely adapted to providing fusible elements of the stepped-type to limit the maximum peak voltage which results during an interrupting operation to thereby permit a reduction in the longitudinal dimension of the overall fuse structure or a more compact fuse structure for a particular voltage rating. A further advantage of the disclosed fuse structure where the end portions of each fusible element have a relatively greater cross-sectional area than the associated intermediate portion is that the relatively larger end portions assist in preventing possible damage to the associated end terminals or end caps that might otherwise result as previously described. Finally, in a fuse structure as disclosed, the portion of the support member which is exposed to arcs during an interrupting operation of the fuse structure is limited or controlled due to the limited contact between the fusible element 40 and the associated support member 30, at the limited number of locations on the support member 30 at which the fusible element 40 is supported.

I claim as my invention:

1. A fuse structure comprising a generally tubular, electrically insulating casing, terminal means disposed adjacent to each of the opposite ends of said casing, a fusible element disposed in said casing and connected between said terminal means, an axially extending, electrically insulating support member disposed in said casing with the ends disposed adjacent to and axially spaced from the respective terminal means to provide a predetermined axial spacing between each end of said support member and the respective terminal means, said support member including a plurality of axially spaced recesses, the intermediate portion only of said fusible element being disposed on said support member and each of the end portions of said fusible element extending axially between one end of said support member and the adjacent terminal means, said support means being formed from a material which is adapted to evolve gases in the presence of any arc which results when said fusible element melts to aid in arc extinction and a quantity of pulverulent, arc-quenching material disposed in said casing in contact with said fusible element, said predetermined spacing between each end of said support member and the respective terminal means cooperating with said axially spaced recesses to insure that an axially extending electrically conducting path does not occur during the operation of said fuse structure due to excessive gases being evolved from said support member.

2. The combination as claimed in claim 1 wherein said fusible element is formed from electrically conducting material of the flat ribbon type having periodically spaced restricted portions along its length, the intermediate portion of said fusible element including a plurality of turns helically disposed on said support member.

3. A fuse structure comprising a generally tubular, electrically insulating casing, terminal means disposed adjacent to each of the opposite ends of said casing, a fusible element disposed in said casing and connected between said terminal means, an axially extending, electrically insulating support member disposed in said casing with the ends disposed adjacent to and spaced from the respective terminal means, the intermediate portion only of said fusible element being disposed on said support member, and each of the end portions of said fusible element extending axially between one end of said support member and the adjacent terminal means, said fusible element being formed from electrically conducting material of the flat ribbon type having periodically spaced restricted portions along its length, the intermediate portion of said fusible element including a plurality of turns helically disposed on said support member, said fusible element being formed from an electrically conducting fusible material of substantially a predetermined length with each of the end portions of said fusible element being formed by bending each of the respective ends of said fusible material back on itself to increase the effective cross-sectional area of each of said end portions compared with that of said intermediate portion.

4. The combination as claimed in claim 3 wherein the corresponding adjacent restricted portions of the fusible material which is bent back on itself to form each of said end portions are substantially aligned with each other.

5. The combination as claimed in claim 3 wherein said support means is formed from a material which is adapted to evolve a gas which aids in arc extinction in the presence of any arc which results when said fusible element melts.

6. The combination as claimed in claim 4 wherein said support means is formed from a material which is adapted to evolve a gas which aids in arc extinction in the presence of any arc which results when said fusible element melts.

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