United States Patent [19]

Salzer

[11] **3,810,061**

[45] **May 7, 1974**

[54] **HIGH-VOLTAGE FUSE**

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[73] Assignee: **The Chase-Shawmut Company,** Newburyport, Mass.

[22] Filed: **Dec. 4, 1972**

[21] Appl. No.: **312,191**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 161,089, July 9, 1971.

[52] **U.S. Cl.** **337/159,** 337/231, 337/238, 337/240, 337/290, 337/295

[51] **Int. Cl.** **H01h 85/04**

[58] **Field of Search** 337/158, 159, 160, 161, 337/231, 238, 239, 240, 290, 293, 295

[56] **References Cited**

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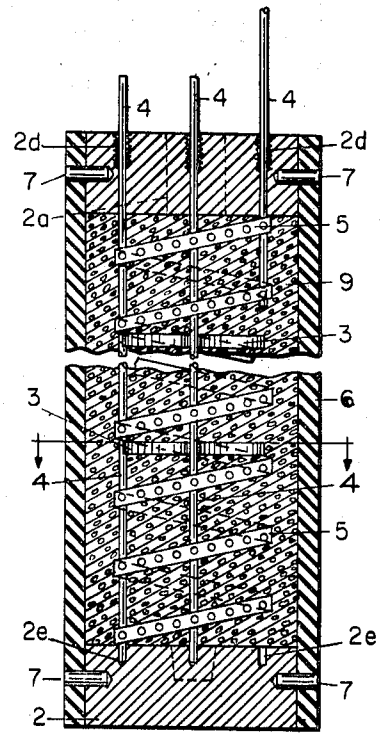
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Primary Examiner—Bernard A. Gilheany
Assistant Examiner—E. E. Bell

[57] **ABSTRACT**

A high-voltage fuse having plug terminals a plugged casing, bores in one of the plug terminals, rods removably mounted in the bores of the casing, which form a temporary support for a fusible element wound substantially helically around the aforementioned rods. In the resulting fuse the conventional mandrel of electric insulating or ceramic material generally star-shaped in cross-section is dispensed with. The aforementioned rods are withdrawn when the pulverulent arc-quenching filler filled into the casing provides sufficient support for the long and fragile fusible element or elements. An annular or tubular element of electric insulating material is arranged along the axis of the fuse structure in such a way that it braces the temporary supporting rods for the fusible element or elements against the pressure exerted by the latter, tending to bend said rods radially inwardly. The annular or tubular element may be adapted to perform additional functions.

6 Claims, 12 Drawing Figures



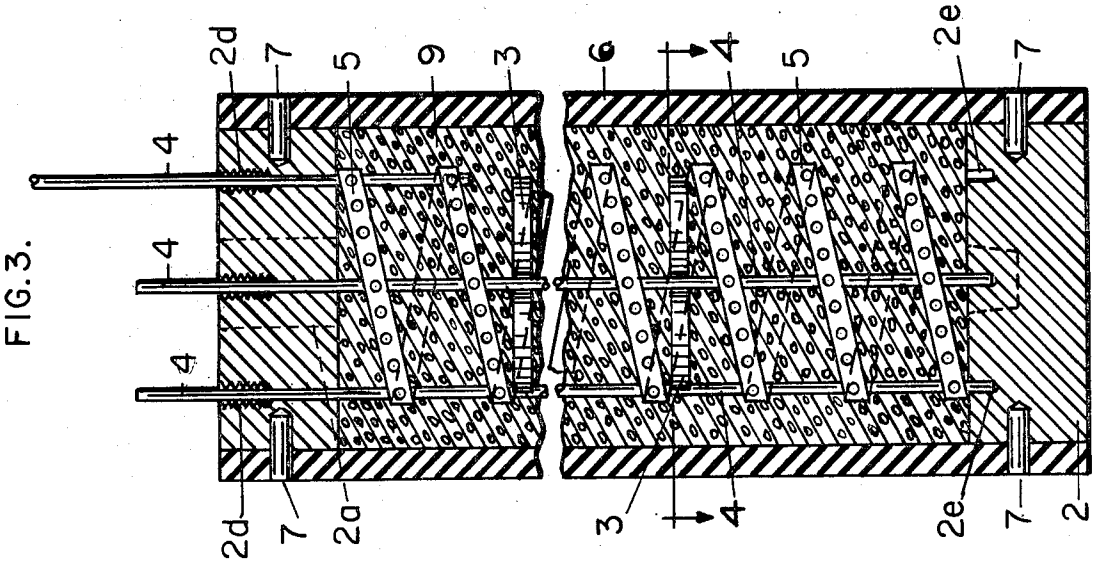


FIG.3.

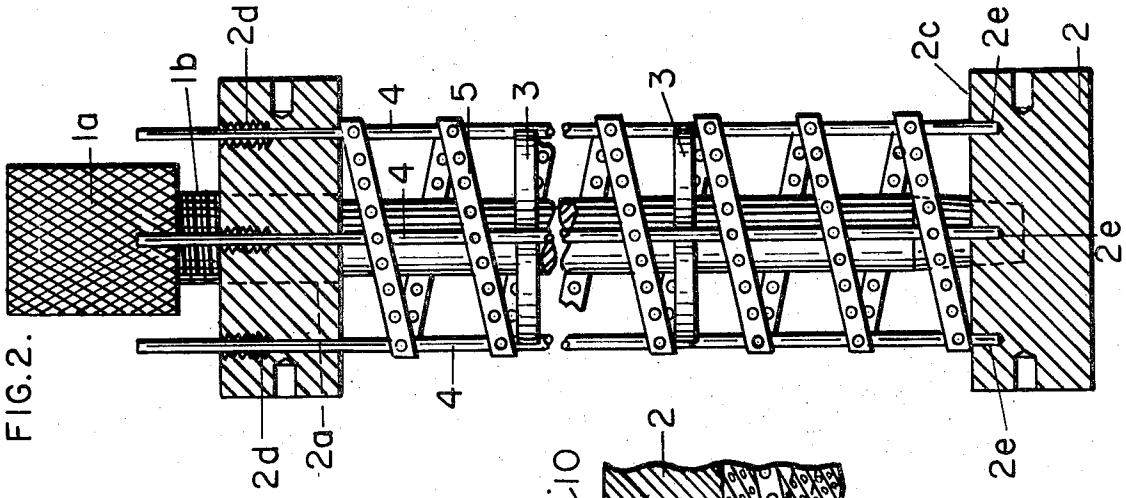


FIG.2.

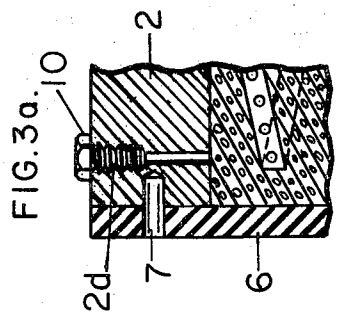


FIG.3a.

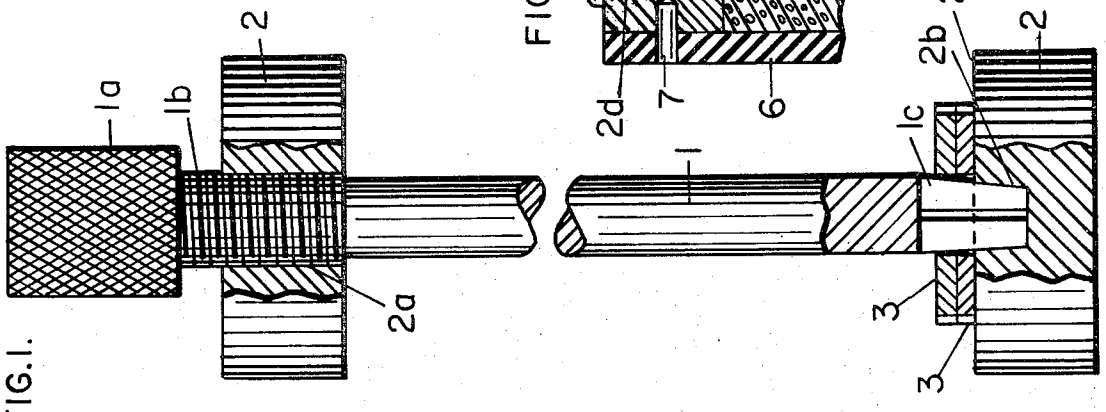


FIG.1.

FIG.4.

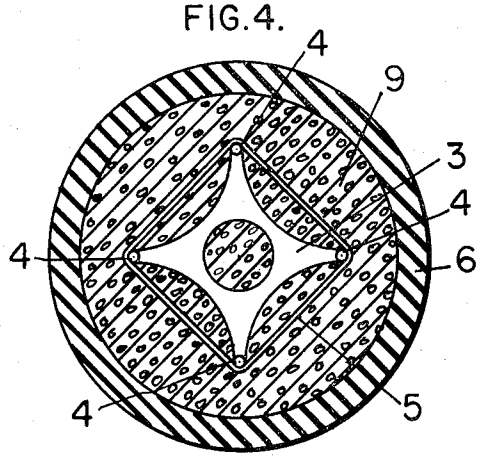


FIG.5.

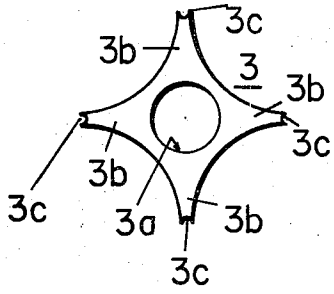


FIG.6.

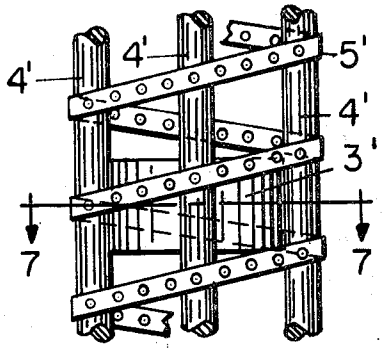


FIG.7.

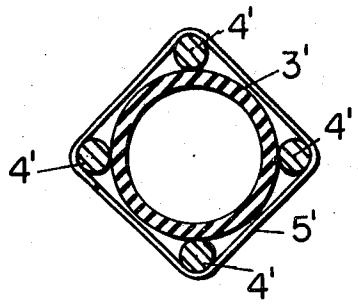


FIG.8.

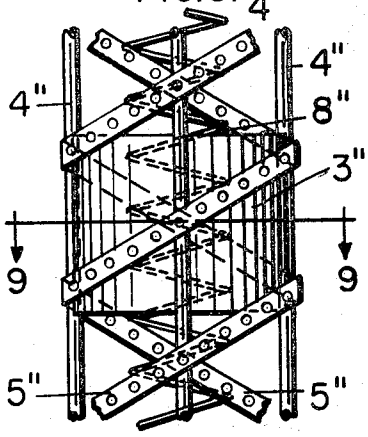


FIG.10.

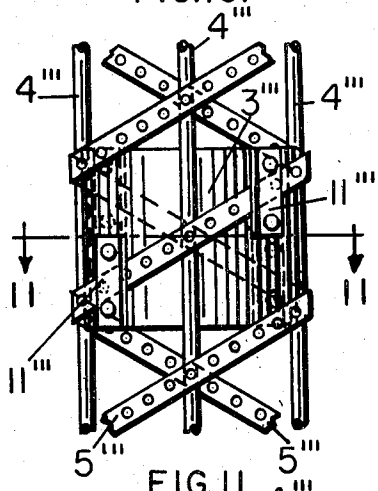


FIG.9

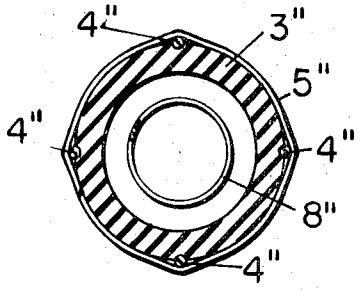
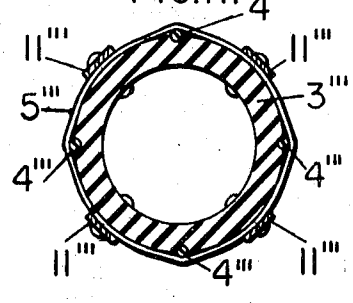


FIG.11.



HIGH-VOLTAGE FUSE

BACKGROUND OF THE INVENTION

This is a continuation in part of the copending patent application of Erwin Salzer filed 7/9/71, Ser. No. 161,089 for METHOD OF ASSEMBLING HIGH-VOLTAGE FUSES AND SUBASSEMBLY THEREFOR.

The process disclosed in the above referred-to patent application includes the step of inserting a plurality of rods into bores in one of a pair of plug terminals and causing the ends of said plurality of rods remote from said one plug terminal to engage corresponding bores in the other said pair of plug terminals while being maintained in coaxial relation to said one of said pair of plug terminals. Thereupon a fusible element is wound substantially helically around said plurality of rods, and the ends thereof are conductively connected to the axially inner end surfaces of said pair of plug terminals. The sub-assembly thus formed (including the pair of plug terminals, the rods and the helically wound fusible element) is inserted into a tubular casing of electric insulating material. This is achieved by fitting said pair of plug terminals into said casing while maintaining said pair of plug terminals and said casing in coaxial relation. Thereupon the casing is affixed to the pair of plug terminals. Then the casing is filled with a pulverulent arc-quenching filler through a bore in said one of said pair of plug terminals, and the aforementioned rods are withdrawn through said bores in said one of said pair of plug terminals from portions of said fusible element sufficiently supported by said filler by exerting a pull upon ends of said plurality of rods projecting through said bores in said one of said pair of plug terminals beyond the axially outer end surface thereof.

The application Ser. No. 161,089 states different ways of withdrawing the rods used as temporary supports for a fusible element, or fusible elements. In some instances it is preferable to withdraw the rods sequentially and in other instances it is preferable to withdraw the rods simultaneously. Whatever the particular timing of the rod-withdrawing step or steps, the fundamental fact underlying any withdrawal of temporary supporting rods for a helically wound fusible element is the formation of voids at points previously occupied by the rods and formed by the withdrawal of the rods. These voids must thereafter be filled with pulverulent arc-quenching filler. The relative ease or relative complexity of filling these voids with said filler depends upon many factors as, for instance, the nature of the pulverulent arc-quenching filler, the geometry and size of its constituent particles, the friction between its constituent particles, the density of packing of particles, etc. Aside from all these variables affecting the filling of the voids formed by retraction or withdrawal of the rods forming temporary supports for the fusible element, all other conditions being equal, the process of filling a fuse with pulverulent arc-quenching filler is eased to a progressively increasing extent, the smaller the volume of the aforementioned voids or, in other words, the smaller the diameter of the rods used for temporary support of the fusible element. The ideal limit case, therefore, would be to provide rods which are so rigid and so thin that their diameter could be zero, leaving voids whose volume would be zero.

One step in the right direction is to use a center post for spacing the plug terminals when assembling the fuse as described in the aforementioned parent patent application Ser. No. 161,089 and as will be described below more in detail. The use of such a center post relieves the rods used as temporary support for the fusible element or elements of their plug terminal spacing duty and limits their function to that of temporarily supporting the fusible element or elements, thereby making it possible to greatly reduce the diameter thereof. Considering a fuse of considerable length intended for a relatively high circuit voltage, the combination of both rod-diameter-reducing measures, i.e., using stiff or rigid rods and relieving the rods from their plug terminal spacing function by providing the fuse sub-assembly with a temporary center post are not sufficient to allow a reduction of the diameter of the rods to such an extent as desired to facilitate the filling process as much as possible or, in other words, to allow optimization of the fuse filling processes. If the casing of the fuse is relatively long, i.e., in excess of 20 inches and the diameter of the rods is made as small as desired to minimize the volume of the voids formed upon removal thereof, the radial inward pressure of the fusible element or elements wound around the rods has a tendency to bend the latter radially inwardly, even if the rods are made of a material having an extremely high modulus of elasticity. Such radial inward bending of the temporary supporting rods for the fusible element is very detrimental because it results during the process of winding the fusible element helically around the rods in some displacement of portions of the fusible element relative to the rods. The very undesirable tendency of extremely thin fusible element supporting rods to bend can be avoided by arranging a bracing means of electric insulating material between the ends of the rods capable of effectively bracing the rods against the radially inwardly directed pressure exerted by the helically wound fusible element upon its temporary supporting rod. The aforementioned bracing means must have a central aperture and be arranged in substantially coaxial relation to the casing in order to make it possible to properly fill the casing with a central jet of pulverulent arc-quenching filler flowing through the aforementioned central aperture in the aforementioned bracing means.

SUMMARY OF THE INVENTION

The essence of the invention resides in the provision of a bracing means of the aforementioned character for the rods which form a temporary support for the fusible element or elements. This bracing means is preferably used in conjunction with a center post for spacing the terminal plugs during the process of assembly to relieve the supporting rods of the fusible winding from the plug terminal spacing duty so that the duty of these rods is limited to temporarily support the fusible element, or elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** to **3**, inclusive, show partly in elevation and partly in longitudinal section three consecutive phases of assembling a high-voltage fuse in accordance with the present invention;

FIG. **3** shows substantially in cross-section a detail of a complete fuse embodying the present invention;

FIG. **4** is a cross-section along **4—4** of FIG. **3**;

FIG. 5 is a top plan view of a detail of FIG. 4;

FIG. 6 shows in front view a modification of a portion of the structure of FIGS. 2 and 3;

FIG. 7 is a section along 7—7 of FIG. 6;

FIG. 8 shows in front view another modification of the structure of FIGS. 1 and 2;

FIG. 9 is a section along 9—9 of FIG. 8;

FIG. 10 shows in front view still another modification of the structure of FIGS. 1 and 2; and

FIG. 11 is a section along 11—11 of FIG. 10.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, and more specifically to FIGS. 1–5 thereof, reference character 1 has been applied to indicate a relatively thick center post for spacing a pair of plug terminals 2. Spacing post 1 is provided with a knurled handle portion 1*a* and an externally screw-threaded portion 1*b* engaging a corresponding internally screw-threaded portion 2*a* in the center of upper plug terminal 2. The lower plug terminal 2 is provided in the center thereof with a blind recess 2*b* substantially in the shape of a frustrum of a cone. Center post 1 is provided with a radially slotted relatively resilient end portion 1*c* which has the same shape as recess 2*b* and is intended to engage recess 2*b* and to firmly connect post 1 in a non-permanent fashion to lower plug terminal 2.

The first steps in assembling a fuse in accordance to the present invention consist in screwing post 1 into upper plug terminal 2, sliding post 1 through one or more annular elements 3 of electric insulating material and thereafter press-fitting part 1*c* of post 1 into recess 2*b*, thus firmly spacing plug terminals 2 from each other. As shown in FIG. 1 the annular elements or spiders 3 then rest on the axially inner end surface 2*c* of lower plug terminal 2. Plug terminals 2 are spaced by post 1 in coaxial relation.

FIG. 5 is a top plan view of one of the annular elements or spiders of FIG. 1. It is apparent from FIG. 5 that part 3 has a central circular aperture 3*a* which serves several purposes as will be explained below more in detail. In the process of assembling the fuse structure post 1 is inserted into the central aperture 3*a* before its end 1*c* is inserted into recess 2*b*.

As shown in FIG. 5 annular element or spider 3 is provided with four arms 3*b* which are angularly displaced 90°. The radially outer ends of arms 3*b* form small semicircular recesses 3*c*.

Referring now to FIG. 2, upper plug terminal 2 is provided with four axially extending passageways 2*d* and the lower plug terminal 2 is provided with four blind bores 2*e* arranged in registry with passageways 2*d*. The latter extend from the upper or axially outer end surface of upper plug terminal 2 to the lower or axially inner end surface thereof.

The next step in assembling the fuse structure embodying this invention consists in inserting four relatively thin, or small diameter rods 4 into bores or passageways 2*d* in such a way that the lower ends of rods 4 engage the blind holes or bores 2*e*. The lower ends of rods 4 then also engage the semi-circular recesses 3*c* in the arms 3*b* of insulating spiders 3. Thereupon insulating spiders 3 are raised from their lower level shown in FIG. 1 to higher levels shown in FIG. 2. Now post 1, plug terminals 2, rods 4 and insulating spiders 3 form a squirrel-cage-like structure of considerable dimensional stability, even if the diameter of rods 4 is very small. This high degree of dimensional stability is primarily due to two facts, i.e., the fact that post 1 spaces plug terminals 2, relieving rods 4 from that function, and the fact that rods 4 are braced by spiders 3 at two points intermediate the axially inner end surfaces of plug terminals 2.

After a high degree of dimensional stability is imparted to rods 4 by proper positioning of spiders 3, one or more fusible elements or ribbon fuse links 5 are wound substantially helically around rods 4 and the ends of fusible elements or fuse links 5 are conductively connected to the axially inner end surfaces of plug terminals 2. This may be achieved in the fashion set forth in detail in U.S. Pat. No. 3,571,775 to Frederick J. Kozacka et al., 3/23/71 for HIGH-VOLTAGE FUSE HAVING A PLURALITY OF HELICALLY WOUND RIBBON FUSE LINKS.

When the fuse link winding process is completed and the ends of the fuse links 5 are conductively connected to parts 2, the latter are press-fitted in coaxial relation into a tubular casing 6 of insulating material, e.g., melamine-glass-cloth, as shown in FIG. 3. At this time parts 1,2,4 and 5 form a subassembly and are jointly inserted into casing 6. Then casing 6 is affixed to plug terminals 2 by means of steel pins 7 projecting radially inwardly through casing 1 into plug terminals 2. At this point of the process of assembly casing 6 becomes a means for spacing plug terminals 2. Therefore spacing post 1 may be unscrewed and withdrawm from casing 6 and plug terminals 2. This clears the internally screw-threaded aperture 2*a* in upper plug terminal 2 heretofore obstructed by the screw-threaded portion 1*b* of post 1. Upon removal of post 1 and opening of screw-threaded bore 2*a* a pulverulent filler 9, preferably quartz sand, is filled through the latter into casing 6. Filler 9 flows down in form of a jet through apertures 3*a* in spiders 3.

Finally rods 4 are withdrawn through bores 2*d* in upper plug terminal 2 from portions of ribbon fuse link or ribbon fuse links 5 sufficiently supported by filler 9 by exerting a pull upon the ends of rods 4 projecting through bores 2*d* beyond the axially outer end surface of the upper plug terminal 2.

The assembly process of the fuse is completed by plugging bores 2*d*, e.g., by means of plug screws 10 as shown in FIG. 3*a* and explained more in detail in the parent patent application Ser. No. 161,089.

Rods 4 may be withdrawn from winding 5 and casing 6 sequentially or simultaneously as set forth more in detail in the patent application Ser. No. 161,089, provided that the portions of fusible element or elements from which rod supports 4 are withdrawn are sufficiently supported by pulverulent arc-quenching filler at the time of withdrawal of the rod supports therefrom.

The apertures 3*a* in insulating spiders 3 allow a smooth, unimpeded axial flow of the pulverulent arc-quenching filler from top aperture 2a in upper plug terminal 2 along the axis of casing 1 which is inter alia an essential requirement for optimizing the filling operation.

FIGS. 6 and 7 refer to the same process and the same structure as described above except that in the former a cylindrical or tubular bracing spacer or a short length of insulating tubing 3′ has been substituted for the insulating spiders 3 previously described. Each rod 4′ for supporting temporarily one or more fusible elements 5′

is engaged along a generatrix or a line thereof by the length of bracing tubing 3'. Therefore this method of bracing rods 4' is even more effective than bracing by means of the spiders of FIGS. 3, 4 and 5.

In FIGS. 6 and 7 the diameter of rods 4' has been greatly exaggerated. The true diameter of the temporary fuse-link-supporting rods is shown in FIGS. 1–4 and 8–11 in a more realistic fashion and should actually be even less than suggested by these figures.

As a general rule high-voltage fuses must be provided with means responsive to blowing either for indicating that a given fuse has blown, or for performing a tripping operation in response to blowing of a fuse, e.g., tripping an automatic switch in response to blowing of a back-up fuse. It is good practice to carefully space and insulate the current-carrying helically wound fusible elements of high-voltage fuses from the helically wound fusible wire controlling the blown fuse indicating means of the particular fuse. In fuses having a fuse-link-supporting mandrel of ceramic material the mandrel is generally tubular and its current-carrying fusible ribbon elements are helically wound around the outer surface thereof, while the helically wound wire controlling the blown fuse indicating means is arranged inside the mandrel of ceramic material. A prior art fuse of this description involving a hollow insulating mandrel for separating fusible current-carrying means from fusible control means is disclosed, for instance, in U.S. Pat. No. 3,270,168 to E. Jacks et al., 8/30/1966 for HIGH VOLTAGE FUSE HAVING FLEXIBLY MOUNTED FUSE SUPPORT. Where it is intended to provide a fuse with a helically wound fusible element and blown fuse responsive means but do away or dispense with the conventional hollow ceramic mandrel shown in the above patent, it becomes necessary to provide means for spacing the current-carrying fusible means and the fusible blown fuse responsive means from one another. Such an arrangement is shown in FIGS. 8 and 9.

Referring now to FIGS. 8 and 9, reference character 4'' has been applied to indicate four fuse-link-supporting rods which correspond in every respect to the rods 4 of FIGS. 2 and 3 and described in the context of these figures. The center regions of rods 4'' engage linearly a short length of insulating tubing 3''. A pair of ribbon fuse links 5'' is wound helically around rods 4'' and around part 3''. A helically wound wire 8'' for controlling blown fuse indicating means is arranged inside of the space bounded by the four rods 4'' and is arranged in coaxial relation to tubing 3'' and projects through the latter.

In the structure of FIGS. 6 and 7 the ribbon fuse link 5' does not engage the length of tubing 3'' and upon removal of rods 4' the fusible element 5' is not in physical engagement with any substance other than the surrounding pulverulent filler.

The structure of FIGS. 8 and 9 differs from that of FIGS. 6 and 7 in that in the former the fusible elements 5'' are in physical engagement with the length of tubing 3''. This engagement is not altered when the temporary supporting rods 4'' are removed. The length of tubing 3'' is firmly supported by the surrounding arc-quenching filler upon complete assembly of the fuse structure and, in turn, provides an improved center support for the fusible elements 5''.

The structure of FIGS. 10 and 11 is, in essence, the same as that shown in FIGS. 8 and 9 except for a few changes made in the structure of FIGS. 10 and 11. In that structure four relatively thin rods 4'' corresponding to the rods 4 of FIGS. 2–4 are arranged around a tubular element 3''' of laminate of melamine glass cloth corresponding to the spiders 3 of FIGS. 1–5. The helical blown fuse indicator winding 8'' of FIGS. 8 and 9 has been deleted in the structure of FIGS. 10 and 11. Rods 4''' are slightly recessed in grooves provided in tubular member 3''' and the pair of fusible elements 5''' wound around rods 4''' engage the outer surface of tubular rod bracing member 3'''. Tabs or small plates 11''' of insulating material and the surface of member 3''' sandwich points of ribbon fuse links 5'''. Plates 11''' are a laminate of melamine glass cloth and may be affixed to tubular member 3''' by appropriate fastener means such as, for instance, small rivets, or preferably eyelets. Upon fusion and vaporization of fusible elements 5''' incident to blowing of the fuse a pair of helical fulgurites is formed which are semiconductors and have a relatively good conductivity as long as they are at elevated temperatures. The points where fuse links 5''' are sandwiched between parts 3''' and 11''' do not form fulgurites because when the fuse is fully assembled the purverulent arc-quenching filler surrounding these points has no access to these points, and because the melamine structure at these points evolves large amounts of gas when subjected to arcing, which tends likewise to preclude formation of fulgurites at these points. Since each fusible element 5''' is sandwiched at two points thereof between parts 3''' and 11''', the fulgurite resulting from each fusible element 5''' is interrupted at two points. This results in a drastic decrease of the conductivity of the fulgurites taking the place of fusible elements '' at the time of formation of these fulgurites and immediately thereafter.

It will be apparent that tubular member 3''' of FIGS. 10 and 11 performs three functions.

1. It forms a bracing means for rods 4''' during the process of assembling the fuse structure allowing to minimize the diameter of rods 4''' and to minimize the radially inward bending of rods 4''' under the pressure of helical windings 5'''.

2. It forms an effective support for fusible elements 5''' after the fuse is assembled because its surface is engaged by the fusible elements 5''' and its interface with the surrounding pulverulent arc-quenching filler is much larger than the interface between the pulverulent arc-quenching filler and fusible elements 5''' in the absence of part 3'''.

3. It forms an effective means for interrupting the fulgurites formed incident to blowing of the fuse at one or more points.

In addition to the above the tubular member 3''' may form an effective spacer between the helically wound current-carrying fusible elements and the helically wound fusible element for a blown fuse indicator as described above in connection with FIGS. 8 and 9.

It will be noted from FIGS. 2 and 3 that the bores 2*d* in upper plug terminal 2 are screw-threaded in part in order to receive plug screws 10 shown in FIG. 3*a*. The blind bores 2*e* in lower plug terminal 2 need not to be screw-threaded if a plug-terminal-spacing center post 1 is used in the process of assembly. If such a post is not used, as shown more in detail in the above referred-to copending application Ser. No. 161,089, then the blind bores 2*e* ought to be internally screw-threaded and the portions of the rods temporarily supporting the fusible

winding which engage the blind bores ought to be externally screw-threaded as shown in the above referred-to application Ser. No. 161,089.

When the filling process of casing **6** is completed, the internally screw-threaded large center bore **2a** in upper plug terminal **2** must be plugged, preferably by means of a plug screw as shown in application Ser. No. 161,089. Thus upper plug terminal **2** of a fully assembled fuse will normally be provided with five plug screws, one plugging the large screw-threaded center bore *2a*, and four other smaller plug screws **10**, each plugging the axially outer screw-threaded end of one of small diameter bores *2d* extending parallel to large diameter bore *2a*. Since each of the four bores *2d* is aligned with one of the blind holes *2e*, bores *2d*, *2e* define the locations of the edges of a prism.

It will be apparent from the above that fuses embodying this invention differ from more conventional fuses inasmuch as the fusible element or fusible elements thereof are substantially supported by the arc-quenching filler in the absence of a supporting mandrel approximately equal in length to the spacing of the axially inner end surfaces of the pair of terminal plugs. In the embodiment of the invention shown in FIGS. **8,9,10** and **11** a short length of tubing **3''** and **3'''**, respectively, takes the place of the aforementioned long mandrel. This makes it not only possible to achieve considerable savings, but improves for a number of reasons greatly the operational behavior of the fuse. One of these reasons resides in the fact that there is no possibility of tracking at any point where a supporting mandrel is eliminated.

I claim as my invention:

1. A high-voltage fuse including

a. a tubular casing of electric insulating material;

b. a pair of plug terminals closing the ends of said casing and affixed to the ends thereof, one of said pair of plug terminals having a plugged screw-threaded axial center bore of relatively large diameter in the center thereof and further having a plurality of plugged axial bores of relatively small diameter surrounding said center bore, and the other of said pair of plug terminals having a blind center bore of relatively large diameter in the axially inner end surface thereof and further having a plurality of blind bores of relatively small diameter in the axially inner end surface thereof surrounding said blind center bore, said plurality of bores of relatively small diameter in said one of said pairs of plug terminals and said plurality of blind bores in said other pair of plug terminals being aligned and the lines of alignment thereof defining the locations of edges of a prism;

c. a pulverulent arc-quenching filler inside said casing;

d. a fusible ribbon element in form of a substantially helical winding wound around said lines of alignment and having ends conductively connected to the axially inner end surfaces of said pair of plug terminals, said fusible element being submersed in said arc-quenching filler and substantially supported by said arc-quenching filler in the absence of a supporting mandrel substantially equal in length to the spacing of the axially inner end surfaces of said pair of plug terminals; and

e. at least one insert of electric insulating material inside said winding arranged in axially spaced relation from said axially inner end surfaces of said pair of plug terminals, said insert having a central axial aperture arranged in substantially coaxial relation to said casing and said insert further having surface elements arranged in close proximity to said lines of alignment of said plurality of bores and said plurality of blind bores.

2. A high-voltage fuse as specified in claim **1** including a substantially helically wound wire for controlling a blown fuse indicator, said wire being arranged inside of the prismatic space bounded by said lines of alignment and projecting through said central axial aperture in said insert of electric insulating material and spaced by said insert of electric insulating material from said fusible ribbon element.

3. A high-voltage fuse as specified in claim **1** wherein said insert of insulating material is substantially in the shape of a spider.

4. A high-voltage fuse as specified in claim **1** wherein said insert of insulating material is substantially in the shape of a short length of tubing.

5. A high-voltage fuse as specified in claim **4** wherein the radially inner surface of said fusible element engages the outer surface of said short length of tubing.

6. A high-voltage fuse as specified in claim **4** wherein said short length of tubing consists of a laminate of melamine-glass-cloth and wherein a point of said fusible element is sandwiched between the outer surface of said short length of tubing and a strap of a laminate of melamine-glass-cloth affixed to said short length of tubing.

* * * * *