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Kozacka

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[54] **HIGH-VOLTAGE FUSE HAVING FULL RANGE CLEARING ABILITY**

[75] Inventor: **Frederick J. Kozacka,** South Hampton, N.H.

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

[*] Notice: The portion of the term of this patent subsequent to July 2, 1990, has been disclaimed.

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[52] **U.S. Cl.**..... **337/161,** 337/160, 337/164, 337/166, 337/273, 337/276, 337/293, 337/296

[51] **Int. Cl.. H01h 85/12,** H01h 85/38, H01h 85/08

[58] **Field of Search** 337/160, 161, 163, 164, 337/166, 231, 293, 273, 275, 276, 279, 296

[56] **References Cited**

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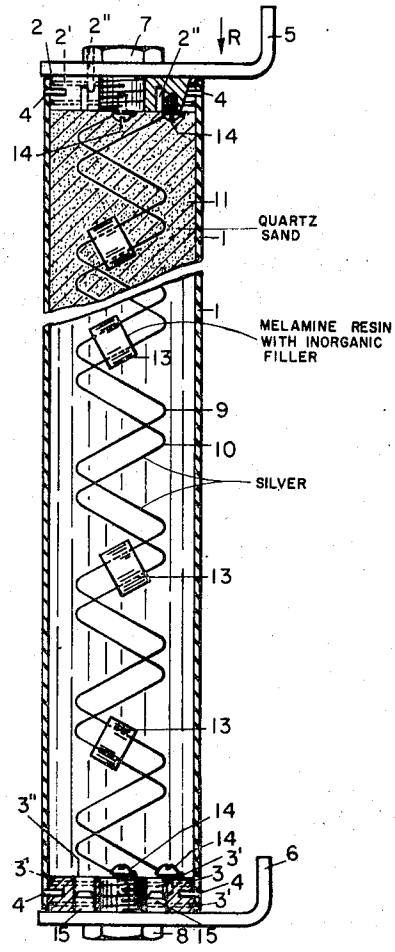
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Primary Examiner—Bernard A. Gilheany
Assistant Examiner—A. T. Grimley
Attorney, Agent, or Firm—Erwin Salzer

[57] **ABSTRACT**

A high-voltage fuse having full range clearing ability, i.e., capable of interrupting overload currents so small that it may take one or even several hours to cause blowing of the fuse on account of the overload currents, and also capable of interrupting major fault currents, and further capable of interrupting all currents between these extremes. This is mainly achieved by threading the fusible elements through relatively large beads of a material having an extremely low thermal conductivity. Each of the beads may be provided with several substantially parallel bores, or passageways, each receiving one of a plurality of helically wound fusible elements. Such multiple bore beads form spacers between a plurality of helically wound fusible elements not supported by a star shaped mandrel structure, add to their support by a pulverulent arc-quenching filler, and tend to maintain an equidistant spacing between such fusible elements.

7 Claims, 3 Drawing Figures



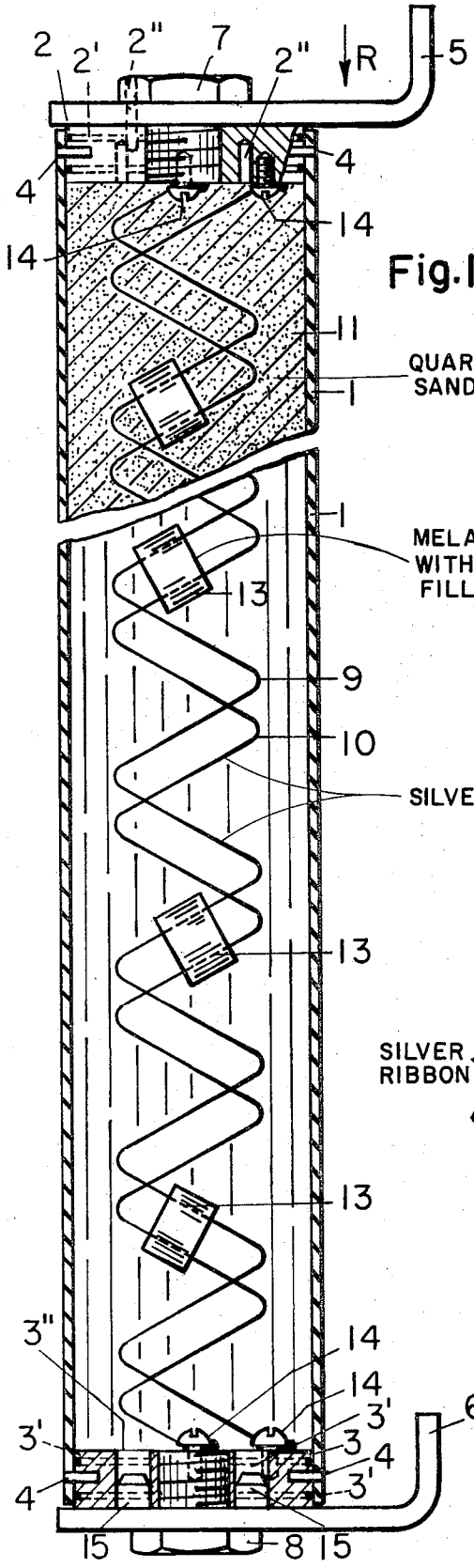


Fig.1

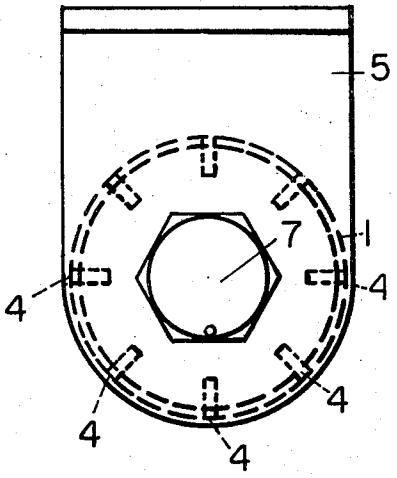
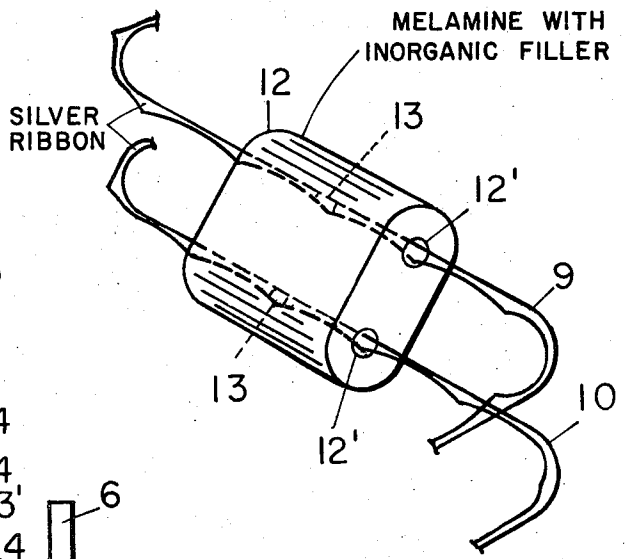


Fig.2

Fig. 3



HIGH-VOLTAGE FUSE HAVING FULL RANGE CLEARING ABILITY

BACKGROUND OF THE INVENTION

To achieve full range clearing ability in high-voltage fuses, e.g., fuses designed for a circuit voltage of 5–15 kV, is one of the most difficult tasks which may be imposed upon such a high-voltage fuse. There are very few fuses in existance capable of complying with the requirement of full range clearing ability, and each of the known designs of this description is subject to serious limitations. It is, therefore, the principal object of this invention to provide full range clearing ability high-voltage fuses not subject to the limitations of the prior art full range clearing ability fuses for elevated circuit voltages.

The fusible elements of high-voltage fuses are often helically wound around a mandrel so that the length of the fusible element may exceed that of the casing, or fuse tube. Such mandrels may be made of an inorganic or ceramic material, or of an organic material. There is no mandrel material in existence that is not adversely affected by the prolonged heating periods of overload currents so small that they cause blowing of the particular fuse only if they persist for at least one hour, or even for several hours. Some mandrel materials have a tendency to emit electrons if subjected to arcing following a long preheating period, other mandrel materials have a tendency to track, and the mandrel materials which perform best under the most onerous conditions are very expensive. It is, therefore, one object of this invention to provide full range clearing ability high-voltage fuses having helically wound fuse links which are not supported by a mandrel.

If a single break is formed in a high-voltage fuse on account of an overload current but slightly exceeding the rated current of the fuse, the burnback velocity of the fusible element is generally too small to generate the arc-voltage required to clear the circuit. The arc voltage required to interrupt the circuit may be generated by assigning the interruption of very small overload currents to a pair of spring-biased separable contacts. This expedient is, however, relatively expensive and increases unduly the bulk of any fuse relying on this method of interrupting very small overload currents. It is, therefore, another object of this invention to provide full range clearing ability high-voltage fuses which do not rely on a pair of spring-biased separable contacts for interrupting very small overload currents.

Very small overload currents can be effectively interrupted by providing means for causing formation of series multi-breaks since series multibreaks are capable of generating sufficiently high arc voltages, even if the rate of burnback at each of the breaks is relatively small. One of the best ways of causing formation of multibreaks at relatively small overload currents is mounting of beads on the fusible element, or on the fusible elements, by threading a fusible element, or fusible elements, through beads. Such beads provide thermal chambers which isolate short sections of the fusible element, or elements, inside of the beads from the surrounding pulverulent arc-quenching filler and cause formation of hot spots along a fusible element, or along fusible elements. Prior art beads have been made of ceramic materials, e.g. of steatite. Extensive tests with prior art beads intended to form series multibreaks along fusible elements and thus to achieve low current interrupting ability failed to achieve full range clearing ability.

It is, therefore, still another object of this invention to provide fuse structures including multibreak-forming beads having full range clearing ability.

SUMMARY OF THE INVENTION

Fuses embodying this invention include a tubular casing of electric insulating material and terminal elements closing the ends of the casing. A fusible element inside the casing interconnects conductively the pair of terminal elements. The fusible element is submersed in a pulverulent arc-quenching filler. The fuses further include means for causing formation of series multibreaks on occurrence of overload currents at least as small as the one hour fusing current and lasting for at least one hour. Said means include a plurality of beads of an insulating material having a thermal conductivity less than 0.50 Btu/hr/sq.ft./°F/ft. mounted on said fusible element and overlays of a metal severing low fusing point metal on said fusible element arranged inside of said plurality of beads.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is mainly a diagrammatic longitudinal section of a fuse embodying this invention, a portion of the fuse between its terminal elements being broken away;

FIG. 2 is a top plan view of the structure of FIG. 1 seen in the direction of the arrow R of FIG. 1; and

FIG. 3 is an isometric view of a detail of the structure shown in FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings, numeral 1 has been applied to indicate a tubular casing of electric insulating material, preferably of glass-cloth melamine. Casing 1 is closed on the ends thereof by terminal plugs 2 and 3. Steel pins 4 project transversely through casing 1 into terminal plugs 2 and 3 to firmly attach the latter to the former. The lateral surfaces of plugs 2 and 3 may be provided with circular grooves 2', 3' which may be filled with a sealing or caulking compound. Angular brackets 5 and 6 are affixed by means of hex screws 7 and 8 to the axially outer surfaces of terminal plugs 2 and 3. Casing 1 houses two helically wound substantially ribbon-shaped fusible elements 9 and 10. Fusible elements 9 and 10 are submersed in a pulverulent arc-quenching filler 11, as indicated in the upper portion of FIG. 1. In the lower portion of FIG. 1 the pulverulent arc-quenching filler has been deleted. Reference character 12 has been applied to indicate beads of which each is provided with a pair of parallel passageways or bores 12'. Fusible elements 9 and 10 are threaded through bores 12' in beads 12 and thus beads 12 tend to maintain the proper and equal spacing between fusible elements 9 and 10 in the absence of a supporting mandrel, spider, or core, for fusible elements 9 and 10. Beads 12 are relatively large and are made of a material having a small thermal conductivity. To be more specific, the material of which beads 12 are made ought to have a thermal conductivity of less than 0.50 Btu/hr/sq ft/°F/ft. The size of passageways or bores 12' is so small as to preclude the particles of pulverulent arc-quenching filler 11 to enter into them and thus to dissipate the heat generated by the portions of fusible elements 9 and 10 inside of beads 12. There are several

beads 12 on each fusible element 9 and 10. Preferably both fusible elements 9 and 10 are provided at each point thereof covered by a bead 12 with a metal severing overlay 13 of a low fusing point metal. The overlays 13 of a low fusing point metal, e.g., tin, are capable of severing upon their fusion the layer of the base metal which supports the overlay. The fusible elements 9 and 10 are preferably of silver, the arc-quenching filler 11 is preferably quartz sand and the material of which beads 12 are made has preferably a thermal conductivity in the order of ¼ the thermal conductivity of steatite. The thermal conductivity of steatite is about 1.45 to 1.94 Btu/hr/sq ft/°F/ft. Ceramics have generally such a high thermal conductivity as to exclude the use thereof for the purposes of this invention. Best results can be achieved with beads of a mixture of a melamine resin and a filler of hydrates or oxides of aluminum known to be anti-tracking substances. A particularly desirable filler material is aluminum trihydroxide. It is, of course, possible to use mixtures of fillers. Materials consisting of a melamin resin and hydrates and oxides of aluminum have a thermal conductivity in the order of 0.32 to 0.41 Btu/hr/sq ft/°F/ft. The thermal conductivity of materials is not a constant but changes with temperature. The above values for thermal conductivity are those at room temperature. At higher temperatures the thermal conductivity may increase significantly. This is not desirable for the purpose of the present invention, but cannot altogether be avoided.

As mentioned above, the size of the beads 12 ought to be relatively large — larger than that of conventional beads for producing hot spots on fusible elements. Cylindrical beads having a length of 9/16 inches and a diameter of 5/16 inches made of melamine resin filled with aluminum trihydroxide have operated very satisfactorily.

The fuse links 9 and 10 have been indicated in FIG. 1 by a pair of helical lines. This is but a diagrammatic representation of the actual geometry of fuse links 9 and 10 which has been more clearly shown in FIG. 3. According to FIG. 3 one edge of fuse links 9 and 10 is straight, and the other edge is formed by aligned circular sections having a radius which is a large multiple of the maximum width of fuse links 9 and 10. The time-current curve of such a fusible element or fuse link is intermediate that of a plain wire and that of a conventional perforated ribbon. Fusible elements 9 and 10 have serially arranged points of reduced cross-section which form series breaks on occurrence of major fault currents. Arc inception occurs at the points of minimum cross-sectional area. The following relatively gradual burnback tends to limit the voltage surge which is generated incident to blowing of the fuse.

The fuse structure shown in FIG. 1 is adapted to be manufactured and is manufactured in accordance with the teachings of the copending patent application of Erwin Salzer, filed July 9, 1971 Ser. No. 161,089 for METHOD OF ASSEMBLING ELECTRIC HIGH VOLTAGE FUSES AND SUBASSEMBLY THEREFOR. Reference may be had to this application for a detailed disclosure of the process of assembly of the structure of FIG. 1. This process will be described below in a general way and without going into details. As shown in FIG. 1 plug 2 is provided with recesses 2'' and plug 3 is provided with recesses 3''. There are preferably four recesses 2'' angularly displaced 90° and four recesses 3'' angularly displaced 90°. Each recess 2'' is arranged in registry with one recess 3'', i.e., one of each of the recesses 2'' and one of each of the recesses 3'' are arranged in coaxial relation. The common axis of each coaxial pair of recesses 2'', 3'' is parallel to the axis of casing 1. The diameter of recesses 3'' is slightly larger than the diameter of recesses 2''. Initially recesses 3'' are provided with bushings which are inserted into them to reduce the inner diameter thereof to that of recesses 2''. Thereupon four stiff rods are inserted into the aforementioned bushings with their ends engaging recesses 2''. Thus a squirrel-cage-like structure is formed by terminal plugs 2, 3 and the aforementioned four rods. While this squirrel-cage-like structure is assembled, plugs 2, 3 are maintained in spaced relation by a center post (not shown) having screw-threaded ends screwed into the screw-threads ultimately occupied by hex screws 7 and 8. The squirrel-cage-like structure is used for winding fusible elements 9, 10 helically thereon. The ends of fusible elements 9 and 10 are clamped by means of screws 14 against the axially inner end surfaces of plugs 2 and 3 and, in addition thereto, conductively connected to said axially inner end surfaces by means of solder joints. This technique of combining fastener screws for fusible elements with solder joints for fusible elements is disclosed more in detail in U.S. Pat. No. 3,571,775 to Frederick J. Kozacka et al., March 23, 1971 for HIGH-VOLTAGE FUSE HAVING A PLURALITY OF HELICALLY WOUND RIBBON FUSE LINKS. The unit formed by terminal plugs 2 and 3, fusible elements 9 and 10 supporting beads 13, and the aforementioned supporting rods for the fusible elements 9 and 10 and the aforementioned center post is inserted into casing 1, whereupon the latter is affixed by steel pins 4 to terminal plugs 2 and 3. At this point of the process of assembly terminal plugs 2 and 3 are spaced by casing 1, and this allows to withdraw the aforementioned center post from casing 1. Thereafter hex screw 7 is inserted into plug 2 and the structure is arranged vertically in such a position that the center hole in plug 3 subsequently closed by hex screw 8 is on top. Now casing 1 is filled with the pulverulent arc-quenching filler 11. When the latter supports fusible elements 9 and 10 and beads 13, the rods previously supporting fusible elements 9 and 10 may be removed. To this end the bushings in recesses or bores 3'' are removed, so that the upper ends of the supporting rods for fusible elements 9 and 10 are not guided any longer in these bushings. The mandrel-forming rods can then readily be removed from the assembly on axial movement thereof equal to, or slightly in excess of the depth of recesses 2, which movement is then followed by a slight radially inward movement of the link-supporting rods. This slight radially inward movement of the supporting rods for the fusible elements causes disengagement of the rods from the latter. As a result, the rods can readily be removed from casing 1 through bores or recesses 3'' without exerting a frictional pull upon fusible elements 9 and 10 in a direction longitudinally of casing 1. Such a pull, if it exists, has a tendency of slightly displacing fusible elements 9 and 10 in a direction longitudinally of casing 1, thus slightly altering the initially equidistant spacing between fusible elements 9 and 10. It is desirable to strictly maintain the equidistant spacing of elements 9 and 10 during the process step of removing the supporting rods thereof. This end is achieved by removing the supporting rods in the fashion set forth above, com-

bined with the action of the dual passage beads 13 tending to maintain the equal spacing between fusible elements 9 and 10. The supporting rods for fusible elements 9 and 10 may be removed sequentially and the small voids resulting from their removal filled instantly with filler 11 by adding some filler through the screw-threaded bore in plug 3 provided for receiving hex screw 8. While filling arc-quenching filler into casing 1 and removing the supporting rods for helical windings 9 and 10, the casing 1 is continuously subjected to vibrations and tapped in transverse direction, if necessary. When the filling of casing 1 is completed, holes or recesses 3'' are closed by plugs 15, and angular bracket 6 is screwed against the axially outer surface of plug 3 by means of hex screw 8. It will be understood that recesses 2'' will be filled with sand or filler 11 following removal of the supporting rods for fusible elements 9 and 10. The arc-quenching filler in the right recess 2'' has not been shown in FIG. 1 in order to emphasize the presence of that recess.

It will be further understood that the multi-passage beads 13 are a means for stabilizing the fusible elements in any fuse structure lacking a central mandrel for supporting the fusible elements and assembled in accordance with the teaching of the aforementioned Salzer patent application.

The hex screw 7 may be provided with a blown fuse indicator as disclosed in U.S. Pat. No. 3,621,433 to Richard A. Belcher, Nov. 16, 1971 for ELECTRIC CARTRIDGE FUSE HAVING PLUG TERMINALS, the angle brackets 5 and 6 then taking the place of the ferrules of the above Belcher structure.

Upon occurrence of a very small overload the temperature of all bead-covered points of fusible elements 9 and 10 increases significantly because the large size and the low thermal conductivity of beads 12 minimizes the heat flow away from the bead-covered points of fusible elements 9 and 10. When the tin or like metal-severing bead-covered overlay on either of fusible elements 9 or 10 fuses, a break is formed at this point. The formation of such a break occurs at relatively small current intensities if their duration is sufficiently long because heat flow away from the overlay metal is minimized on account of the relatively large poorly heat conducting beads. What happens subsequent to formation of one break in one of the fusible elements depends upon a number of factors, in particular upon the temperature distribution along the fuse links. If the temperature distribution is flat, as in most high voltage fuses, series breaks at low current intensities may be obtained with one single fusible element. The following refers to a fuse having two parallel connected fusible elements 9, 10. If a single break is formed in one of fusible elements 9 and 10, e.g., fusible element 9, virtually the entire current will be transferred to the other fusible element, i.e., fusible element 10. Burnback of fusible element 10 will then proceed at a much faster rate that the previous burnback at fusible element 9 and series break will form in fusible element 10, one at each point where a bead 12 is located. As a result, current flow through fusible element 10 will cease, except, perhaps, for a small follow current. During this time the single arc gap in fusible element 9 may have recovered its dielectric strength to such an extent that it cannot be broken down by the circuit voltage. If that arc gap, however, breaks down, this breakdown is followed by a relatively rapid burnback most likely to result in the formation of multibreaks in fusible element 9, which results in final interruption of the overloaded circuit. Small currents can hardly be interrupted through arc elongation only, even in the presence of multibreaks. If the beads 12 are made of a mixture of epoxy resin and of aluminum oxides and/or hydroxides, the beads evolve rapidly flowing currents of gas when subjected to internal arcing, tending to rapidly de-ionize the bead-enclosed sections of the arcs. Thus the beads 12 perform the dual function of establishing series multibreaks at extremely small current intensities and of producing arc-extinguishing axial blasts of gas.

I claim as my invention:

1. An electric current-limiting fuse capable of clearing overload currents equal to or less than the one hour fusing current including

a. a tubular casing of electric insulating material;

b. terminal elements closing the ends of said casing;

c. a fusible element in ribbon form inside said casing having serially arranged points of reduced cross-sectional area conductively interconnecting said pair of terminal elements;

d. a pulverulent arc-quenching filler inside said casing submersing said fusible element; and

e. means for causing formation of series multibreaks in said fusible element on occurrence of overload currents at least as small as the one hour fusing current and lasting for at least one hour, said means including a plurality of overlays of a metal-severing low fusing point metal on said fusible element and a plurality of beads of an electric insulating material having a thermal conductivity less than 0.50 Btu/Hr/sq ft/°F/ft mounted on said fusible element each covering one of said plurality of overlays, the material of said plurality of beads being a mixture of a melamine resin and inorganic fillers and each of said plurality of beads having a length exceeding the spacing between contiguous points of reduced cross-sectional area of said fusible element.

2. An electric fuse as specified in claim 1 wherein said fusible element is of silver, said arc-quenching filler is quartz sand and the material of said plurality of beads has a thermal conductivity in the order of ¼ of the thermal conductivity of steatite.

3. An electric fuse as specified in claim 1 including a plurality of fusible elements connected in parallel and a plurality of beads each having a plurality of bores, each of said plurality of fusible elements being threaded through a bore in one of said plurality of beads.

4. An electric fuse as specified in claim 1 including a plurality of fusible elements formed by a plurality of substantially equidistantly spaced coreless coaxial helical windings wherein each of said plurality of beads has a plurality of parallel equidistantly spaced passageways, said plurality of windings being threaded through said plurality of passageways in said plurality of beads to positively maintain between said plurality of windings the space prevailing between said plurality of passageways in said plurality of beads.

5. An electric high-voltage fuse including

a. a tubular casing of electric insulating material;

b. terminal elements closing the ends of said casing;

c. a plurality of coaxially wound coreless fusible elements inside said casing conductively interconnecting said pair of terminal elements;

d. a plurality of multibore beads, each of said plurality of fusible elements projecting through one of the bores of said plurality of multibore beads and being positively spaced by said multibore beads;

e. a plurality of overlays of a metal-severing low fusing point metal on at least one of said plurality of fusible elements, each of said plurality of overlays being arranged inside a bore of said multibore beads; and

f. a pulverulent arc-quenching filler inside said casing positioning said plurality of fusible elements and said plurality of multibore beads.

6. An electric high-voltage fuse as specified in claim 5 wherein said plurality of multibore beads consist of a melamine resin and an inorganic filler material.

7. An electric high-voltage fuse including

a. a tubular casing of electric insulating material;

b. terminal elements closing the ends of said casing;

c. a plurality of parallel connected fusible elements inside said casing conductively interconnecting said pair of terminal elements;

d. a pulverulent arc-quenching filler inside said casing submersing said fusible elements;

e. a plurality of metal-severing low fusing point overlays on each of said plurality of fusible elements; and

f. a plurality of beads mounted on each of said plurality of fusible elements each covering one of said plurality of overlays and each consisting of a melamine resin with inorganic fillers having a thermal conductivity in the order of ¼ of thermal conductivity of steatite.

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