United States Patent

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[54] **HIGH-VOLTAGE FUSE HAVING INNER CORE AND OUTER SHELL FUSE LINKS**
8 Claims, 3 Drawing Figs.

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[51] Int. Cl. **H01h 85/12**
[50] Field of Search 337/159, 161, 162, 164, 401, 412, 290, 293, 295

[56] **References Cited**

UNITED STATES PATENTS

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ABSTRACT: A high-voltage fuse has ribbon fuse links forming a radially inner core of fuse links and has ribbon fuse links forming a radially outer shell of fuse links. The inner core fuse links are provided with long overload current interrupting neck portions positioned substantially midway between the terminal elements of the fuse. The outer shell fuse links are provided with long overload current interrupting neck portions positioned relatively close to one of the terminal elements of the fuse. The long overload current interrupting neck portions of contiguous outer shell fuse links are arranged in staggered relation.

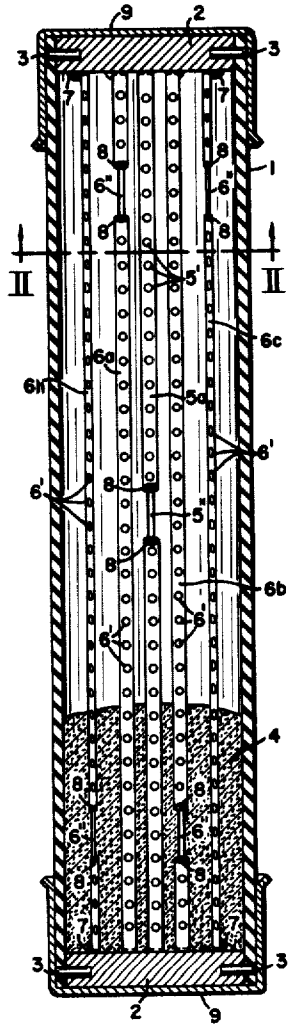


FIG. 1

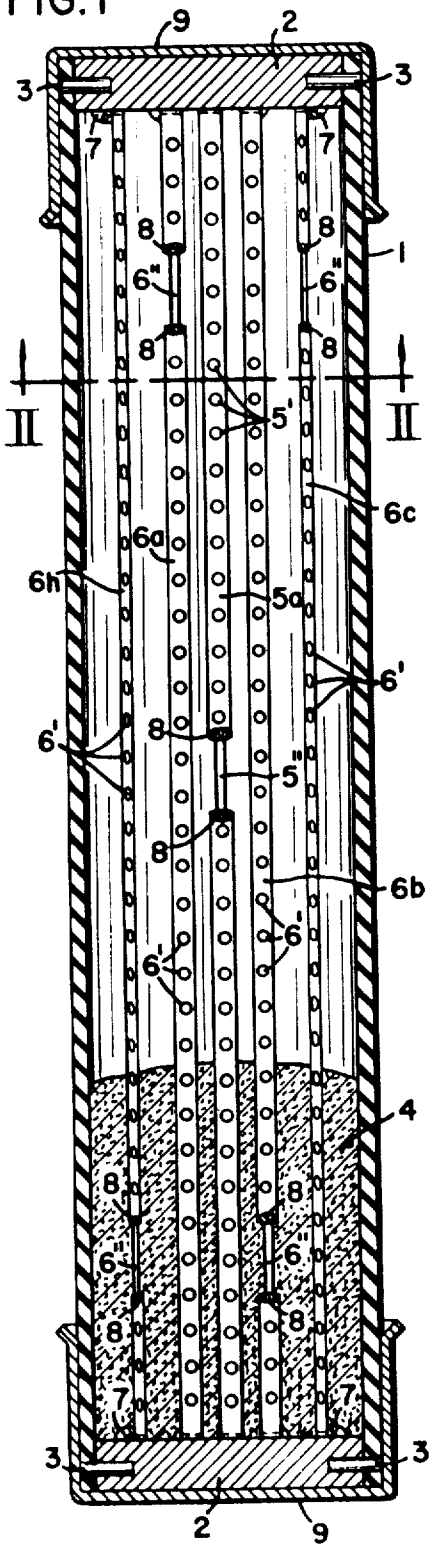


FIG. 2

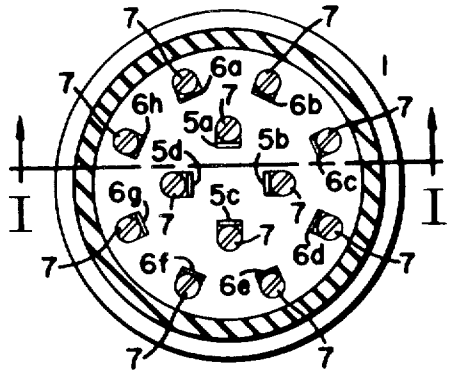
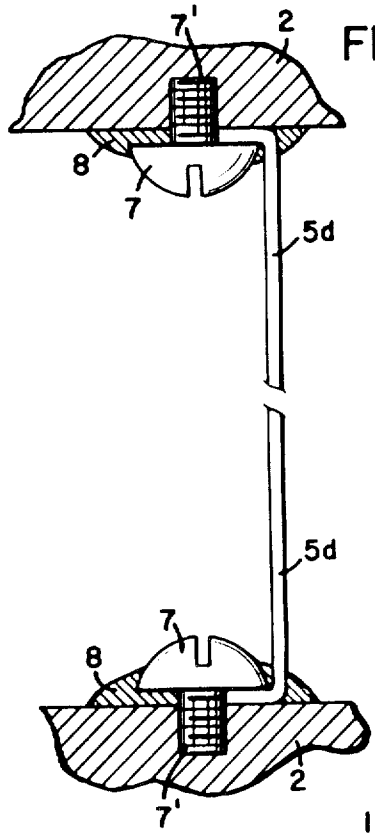


FIG. 3



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HIGH-VOLTAGE FUSE HAVING INNER CORE AND OUTER SHELL FUSE LINKS

BACKGROUND OF INVENTION

High-voltage fuses—e.g. fuses having a voltage rating of 5–15 kv.—intended to carry relatively high currents should preferably be provided with a relatively large number of narrow ribbon fuse links. The relatively large number of ribbon fuse links should be evenly distributed over the cross-sectional area of the casing of the fuse in order to distribute the arc-quenching duty of the pulverulent arc-quenching filler inside of the casing as evenly as possible. As an outgrowth of this consideration a first plurality of fuse links may be arranged to form a radially inner core of fuse links, and a second plurality of fuse links may be arranged to form a radially outer shell of fuse links surrounding the aforementioned core of fuse links.

Ribbon fuse links for high-voltage fuses should be provided with a plurality of serially related relatively short neck portions which form series breaks upon occurrence of major fault currents. If the fuses are intended to interrupt overload currents, in addition to major fault currents, their ribbon fuse links ought to be provided with relatively long, overload current interrupting neck portions, in addition to the aforementioned plurality of serially related relatively short major fault current interrupting neck portions. These relatively long overload current interrupting neck portions are a potential source of trouble on account of the large amounts of heat generated therein. The fulgurites resulting from fusion of the relatively long overload current interrupting neck portions have generally a tendency to merge into a more or less unitary fulgurite adverse to dielectric recovery of the arc gap. If the fuse includes a casing of a synthetic resin, e.g. a casing of a melamine-glass-cloth-laminate, there may be a marked tendency of thermal damage to the casing at points along the casing where the relatively long overload interrupting necks, or the fulgurite resulting from these necks, are located inside of the casing.

The situation is in some respect similar and in other respect very different from that occurring in low-voltage fuses designed for high current ratings as shown, for instance, in U.S. Pat. No. 2,658,974 to Frederick J. Kozacka, Nov. 10, 1953 for "High Current Carrying Capacity Current-Limiting Fuses." In low-voltage fuses neck portions for the interruption of short circuit currents and for the interruption of overload currents may differ in length, but both kinds of neck portions are relatively short in comparison to the long overload current interrupting neck portions found in the ribbon fuse links of high-voltage fuses. Hence the latter necks tend to generate larger amounts of heat and arc energy. In low-voltage fuses the ratio of axial heat transfer to radial heat transfer is relatively large, but in high-voltage fuses, due to their increased length, the ratio of radial heat transfer to axial heat transfer is relatively large. These are some of the reasons why design features of low-voltage fuses have but a limited applicability to high-voltage fuses.

It is the prime object of this invention to provide high-voltage fuses of simple design capable to interrupt effectively major fault currents as well as overload currents.

SUMMARY OF INVENTION

Electric high-voltage fuses embodying this invention include a tubular casing of insulating material, a pulverulent arc-quenching filler inside said casing and a pair of electroconductive terminal elements closing the ends of said casing. A first plurality of ribbon fuse links embedded in said arc-quenching filler and conductively interconnecting said pair of terminal elements is arranged in the center region of said casing. Each of said first plurality of fuse links has a plurality of fuse links, has a plurality of serially related relatively short neck portions and a relatively long neck portion positioned substantially midway between said pair of terminal elements. The fuse further includes a second plurality of ribbon fuse links embedded in said arc-quenching filler, conductively interconnecting said pair of terminal elements, arranged in a peripheral region of said casing and surrounding the constituent fuse links of said first plurality of fuse links. Each of said second plurality of fuse links has a plurality of serially related relatively short neck portions and a relatively long neck portion positioned relatively close to one and relatively remote from the other of said pair of terminal elements, and said relatively long neck portions of contiguous fuse links of said second plurality of fuse links are arranged in staggered relation.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate diagrammatically a high-voltage fuse embodying the present invention.

FIg. 1 being a vertical section along I—I of FIG. 2;

FIG. 2 being a horizontal section along II—II of FIG. 1; and

FIG. 3 being a side elevation of a detail of the structure of FIGS. 1 and 2 drawn on a larger scale than FIGS. 1 and 2.

DESCRIPTION OF PREFERRED EMBODIMENT OF THE INVENTION

In the drawings reference numeral 1 has been applied to indicate a tubular casing of insulating material, e.g. a melamine-glass-cloth-laminate. The casing 1 is closed on the ends thereof by a pair of electroconductive terminal element 2 which may take the form of plugs press-fitted into casing 1 and maintained in position by radial steel pins 3 projecting through casing 1 into plugs 2. Casing 1 is filled with pulverulent arc-quenching filler 4, preferably quartz sand. In order to simplify the pictorial representation of the fuse FIG. 1 shows casing 1 as being only partly filled with quartz sand, or another pulverulent filler 4. Actually the entire casing 1 is filled with a body of pulverulent arc-quenching filler 4. Four ribbon fuse links *5a*, *5b*, *5c*, *5d* form a first plurality of fuse links. These fuse links are embedded in the arc-quenching filler 4, and conductively interconnect terminal elements 2. Ribbon fuse links *5a*, *5b*, *5c*, *5d* are arranged in the center region of casing 1, i.e. their radial spacing from the longitudinal axis of casing 1 is relatively small. Each of fuse links *5a*, *5b*, *5c*, *5d* has a plurality of serially related relatively short neck portions 5′ formed by circular perforations, and each of said fuse links has a relatively longneck portion 5″ positioned substantially midway between terminal elements 2. Reference characters *6a*, *6b*, *6c*, *6d*, *6e*, *6f*, *6g*, *6h* have been applied to indicate the constituent fuse links of a second plurality of fuse links. Fuse links *6a*, *6b*, *6c*, *6d*, *6e*, *6f*, *6g*, *6h* are embedded in arc-quenching filler 4 and interconnect conductively the two terminal elements or plugs 2 of the fuse. They are arranged in a peripheral region of casing 1, i.e. their radial spacing from the longitudinal axis of casing 1 is relatively large, and their radial spacing from the inner surface of casing 1 relatively small. The group of fuse links *6a*, *6b*,...*6g*, *6h* surrounds the group of fuse links *5a*, *5b*, *5c*, *5d*. Each of the second plurality or the second group of fuse links has a plurality of serially related relatively short neck portions 6′ formed by circular perforations, and each of said fuse links has a relatively long neck portion 6″ positioned relatively close to one, and relatively remote from the other, of said pair of terminal elements 2. Relatively long neck portions of contiguous fuse links *6a*, *6b*,...*6g*, *6h* are arranged in staggered relation, i.e. the relatively long neck portions 6″ of fuse links *6a*, *6c*, *6e* and *6g* are arranged relatively close to the upper terminal element 2, relatively remote from the lower terminal element 2, while the relatively long neck portions 6″ of fuse links *6b*, *6d*, *6f*, and *6h* are arranged relatively close to the lower terminal element 2, and relatively remote from the upper terminal element 2.

Each of fuse links *5a*...*5d* and *6a*...*6h* is straight and has ends bent 90° and arranged in abutting engagement with the axially inner end surfaces of terminal plugs, as clearly shown in FIG. 3 referring to ribbon fuse link *5d*. All other fuse links have the same configuration as fuse link *5d* engage terminal elements 2 in the same fashion as fuse link *5d*, and are conductively and

mechanically connected to terminal elements 2 in the same way as fuse link 5*d*. A plurality of screws 7 project with the shanks 7' thereof at right angles into the axially inner end surfaces of terminal plugs 2 and clamp with the heads thereof said ends of fuse links 5*a*...5*d* and 6*a*...6*h* against the axially inner end surfaces of terminal plugs 2. The head of each of screws 7 and the end surfaces of terminal plugs 2 form gaps since they are spaced by the bent ends of fuse links 5*a*...5*d* and 6*a*...6*h*. Drops 8 of soft solder are introduced into these gaps by the capillary action thereof, and solidify therein upon cooling, thus supplementing the mechanical connection of fuse links 5*a*...5*d* and 6*a*...6*h* and plugs 2 by screws 7 by low-voltage drop solder connections, performing the additional function of precluding screws 7 from becoming loose.

It will be noted from FIG. 2 that the constituent fuse links of the first group of fuse links 5*a*...5*d* and the constituent fuse links of the second group of fuse links 6*a*...6*h* are angularly displaced. The circular pitch of fuse links 5*a*...5*d* is much larger than the circular pitch of fuse links 6*a*...6*h*. In the instant case the former is 90° and the latter 45°. The relative positioning of fuse links 5*a*...5*d* and 6*a*...6*h*, and of the long neck portions 5'', 6'' thereof tends to equalize heat generation at any point of the fuse and causes the necks 5' to have at any time slightly higher temperatures than necks 6''. This is primarily due to the fact that links 5*a*...5*d* are surrounded by links 6*a*...6*h*, and that necks 5'' are arranged more remote from terminals 2 than necks 6''. The constituent ribbon links 5*a*...5*d* of the radially inner group of fuse links and the constituent fuse links 6*a*...6*h* of the radially outer group of fuse links are arranged in coaxial cylindrical surfaces, the cylindrical surface in which fuse links 5*a*...5*d* are arranged having a relatively small diameter, and the cylindrical surface in which fuse links 6*a*...6*h* are arranged having a relatively large diameter. To be more specific, fuse links 5*a*...5*d* tangentially engage a cylindrical surface of relatively small diameter, and fuse links 6*a*...6*h* tangentially engage a coaxial cylindrical surface having a relatively large diameter.

In the past high-voltage fuses requiring a relatively high E rating had to include two kinds of pulverulent arc-quenching fillers, i.e. quartz sand and a filler having a smaller thermal conductivity than quartz sand. Fuses according to the present invention may be filled with quartz sand only, excluding any pulverulent arc-quenching filler other than quartz sand, and yet achieve high E ratings.

Preferably a link-severing overlay 8 of a low fusing point metal, e.g. tin, is arranged on both sides of neck portions 5'', 6'' of fuse links 5*a*...5*d* and of fuse links 6*a*...6*h* which are preferably made of silver.

The ratio of the number of fuse links 5*a*...5*d* to the number of fuse links 6*a*...6*h* should preferably be about 1:2. In the embodiment of the invention diagrammatically illustrated it is exactly 1:2. In actual practice the number of fuse links 5*a*...5*d* and 6*a*...6*h* should preferably be larger than shown in the drawing, while the aforementioned ratio still holds. For instance, fuses having a voltage rating up to 5½ kv. and an E rating of 200 to 400 which were successfully tested included 8 inner core fuse links and 16 outer shell fuse links.

Necks 5'' and 6'' may be formed by providing fuse links 5*a*...5*d* and fuse links 6*1*...6*h* with lateral rectangular incisions produced by appropriate stamping operations of blanking operations. Preferably, however, necks 5'' and 6'' are formed by relatively short sections of parallel connected pairs of round silver wire spotwelded at the ends thereof to spaced portions of fuse links 5*a*...5*d* and fuse links 6*a*...6*h*. These spot welds do not appear in the drawing since they are covered by overlays 8.

As mentioned above, and for the reasons mentioned above, the temperature of necks 5'' tends to exceed the temperature of necks 6'', assuming the geometry of all the fuse links 5*a*...5*d* and 6*a*...6*h* being identical, except for the location of the long necks 5'' and 6''. Hence, on occurrence of overload current the necks 5'' of fuse links 5*a*...5*d* will fuse, or the overlays 8 of fuse links 5*a*...5*d* will sever these fuse links at a point of time when fuse links 6*a*...6*h* have not yet reached at any point thereof the temperature required to initiate their interruption. When fuse links 5*a*...5*d* are severed, the rate of current flow through links 6*a*...6*h* will be drastically increased, resulting in rapid formation breaks at neck portions 6''. This normally terminates the low current or overload current interrupting process. The transient recovery voltage appearing across the breaks formed in fuse links 5*a*...5*d* may cause a breakdown at these breaks, but it has been found that these breaks are capable of quickly interrupting any arcing formed by such a breakdown.

On occurrence of major fault currents series arcs are formed virtually simultaneously at the short necks 5' and 6' of fuse links 5*a*...5*d* and fuse links 6*a*...6*h*, respectively.

The fuses shown may be adapted for insertion into any kind of fuse holder. As shown in the drawings the fuses are provided with cylindrical terminal caps 9 conductively connected (by means not shown) with terminal plugs 2, thus making it possible to insert the fuse into a fuse holder having contacts adapted to receive cylindrical terminal caps.

I claim as my invention:

1. An electric high-voltage fuse including:
   a. a tubular casing of insulating material;
   b. a pulverulent arc-quenching filler inside said casing;
   c. a pair of electroconductive terminal elements closing the ends of said casing;
   d. a first plurality of ribbon fuse links embedded in said arc-quenching filler, conductively interconnecting said pair of terminal elements and arranged in the center region of said casing, each of said first plurality of fuse links having a plurality of serially related relatively short neck portions and a relatively long neck portion positioned substantially midway between said pair of terminal elements; and
   e. a second plurality of ribbon fuse links embedded in said arc-quenching filler, conductively interconnecting said pair of terminal elements, arranged in the peripheral region of said casing and surrounding the constituent fuse links of said first plurality of fuse links, each of said second plurality of fuse links having a plurality of serially related relatively short neck portions and a relatively long neck portion positioned relatively close to one and relatively remote from the other of said pair of terminal elements, and said relatively longneck portion of contiguous fuse links of said second plurality of fuse links being arranged in staggered relation.

2. An electric high-voltage fuse as specified in claim 1 wherein
   a. said pair of terminal elements is formed by a pair of plugs inserted into the ends of said casing; wherein
   b. each of said first plurality of fuse links and each of said second plurality of fuse links is straight and has ends bent 90° and arranged in abutting engagement with the axially inner end surfaces of said pair of plugs; wherein
   c. a plurality of screws projecting with the shanks thereof at right angles into said axially inner end surfaces of said pair of plugs clamp with the heads thereof said ends of each of said first plurality of fuse links and said ends of said second plurality of fuse links against said axially inner end surfaces of said pair of plugs; and wherein
   d. the heads of each of said plurality of screws and said axially inner end surfaces of said pair of plugs form gaps being filled with solder.

3. An electric fuse as specified in claim 1 wherein the constituent ribbon fuse links of said first plurality of fuse links and the constituent fuse links of said second plurality of fuse links are angularly displaced.

4. An electric fuse as specified in claim 1 wherein the constituent ribbon fuse links of said first plurality of fuse links are arranged in a first substantially cylindrical surface having a relatively small diameter, wherein the constituent ribbon fuse links of said second plurality of fuse links are arranged in a second substantially cylindrical surface having a relatively large diameter, and wherein said first surface and said second surface are arranged in coaxial relation to said casing.

5. An electric fuse as specified in claim 1 wherein said pulverulent arc-quenching filler is quartz sand excluding any pulverulent arc-quenching filler other than quartz sand.

6. An electric fuse as specified in claim 6 wherein a link-severing overlay of a low fusing point metal is arranged on both ends of said relatively long neck portion of each of said first plurality of ribbon fuse links and on both ends of said relatively long neck portion of each of said second plurality of ribbon fuse links.

7. An electric fuse as specified in claim 1 wherein the ratio of the number of ribbon fuse links in said first plurality of ribbon fuse links to the number of ribbon fuse links in said second plurality of ribbon fuse links is about 1:2.

8. An electric fuse as specified in claim 5 wherein said relatively long neck portion of each of said first plurality of ribbon fuse links and said relatively long neck portion of each of said second plurality of ribbon fuse links is formed by a pair of round parallel-connected wires provided adjacent the ends thereof with a link-severing overlay of a low fusing point metal.