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Mikulecky

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[54] **CURRENT LIMITING FUSE**

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[52] **U.S. Cl.** **337/273,** 337/159, 337/293

[51] **Int. Cl.** **H01h 85/38**

[58] **Field of Search**......................337/158, 159, 161, 337/273, 274, 278, 293, 229, 231, 237; 174/137 R, 212

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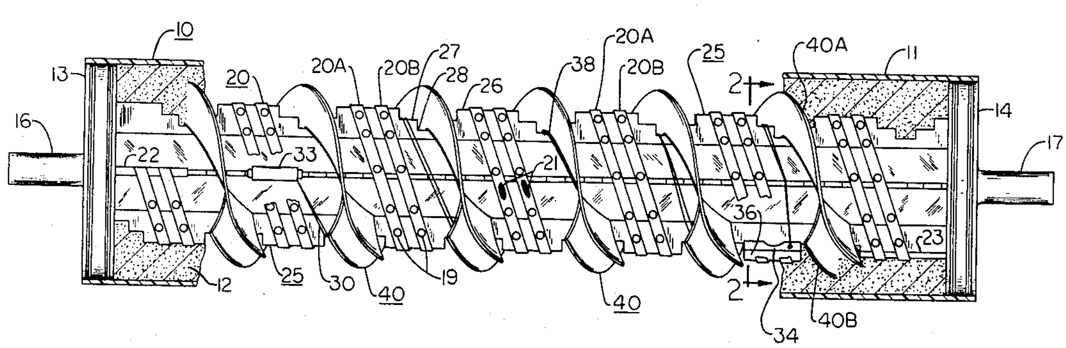
[57] **ABSTRACT**

A current limiting fuse in a tubular casing has sand or highly divided quartz surrounding a fusible element helically wound on a core or spider. The fusible element is connected at its ends to electrical connecting terminals that enable connecting the fuse into the protected circuit. An auxiliary winding is helically wound over a portion of the length of the spider and has gap electrodes connected at each end. The gap electrodes are positioned adjacent the main element and are separated therefrom by a porous fiberglass member. A radially outwardly extending mica barrier is helically wound around the spider to extend between adjacent portions of the fusible element. The barrier is attached to the spider with a heat resistant adhesive, and the auxiliary elements are imbedded in the adhesive along a portion of its length.

15 Claims, 3 Drawing Figures



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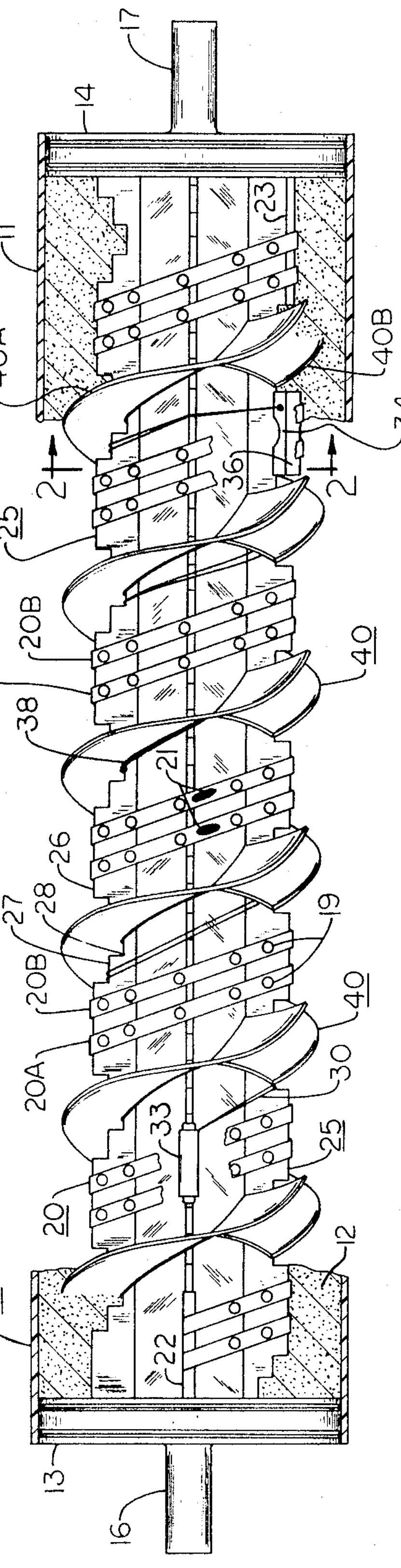

FIG. 1

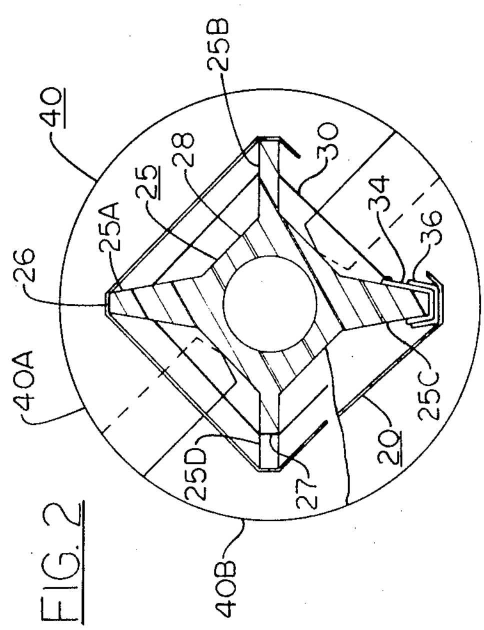

FIG. 2

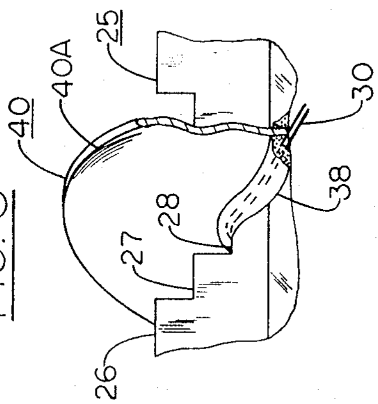

FIG. 3

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CURRENT LIMITING FUSE

This invention relates to current limiting fuses, particularly fuses of the type having a helically wound fusible element within the fuse.

Common current limiting fuses of the general type disclosed typically have a fusible element imbedded in a granulated inert material with high dielectric strength, such as sand or finely divided quartz. The fusible element usually consists of one or more thin conductors wound on a supporting core, or spider, of high temperature resistant material. Upon the occurrence of a fault magnitude overcurrent, the fusible element is raised to fusing temperature and vaporizes. The physical contact between the arc produced at the fusing point and the granules of inert material provides a rapid transfer of heat from the arc to the granules which thereby dissipates most of the arc energy without creating excessive pressure buildup within the fuse enclosure. The vapors of the fusible element at the lower encountered temperatures have a relatively low conductivity, and the temperature is maintained at such low level and reduced by the granules sufficiently to suppress the flow of current. In this manner a high resistance is inserted in the path of the current upon the occurrence of an overcurrent of fault magnitude.

At higher temperatures the particles in the immediate vicinity of the arc become partial conductors of the arc and form a fulgurite, or semiconductor, which is a fusion and sintering of the sand particles to produce a glass-like body which loses its conductivity as it cools and thereby functions as an insulator.

The high voltage, high amperage current limiting fuses used to control fault currents of both low and high magnitude usually employ fusible elements of silver ribbon having portions of relatively small cross-sectional area with intermediate portions of relatively large cross-sectional areas, such as a silver ribbon having a plurality of spaced-apart perforations. The perforations create portions of reduced cross-sectional area which limit the peak arc voltage at high current interruptions and make it possible to distribute the heat from the arcs relatively evenly over the entire filler body. If such a fuse is subject to fault currents of high magnitude, all the portions of small cross-sectional areas fuse and vaporize almost simultaneously, resulting in the formation of arcs in series, thereby controlling the transient voltage across the fuse.

When such a fuse is subjected to small fault currents, the arc gap first formed is generally progressively enlarged by vaporization of the silver element until the gap is of sufficient length to finally interrupt the circuit.

To provide for reliable interruption at small overcurrents, an auxiliary element is often used that is generally wound in the same manner as the main fusible element and is connected at its ends to a gap electrode that separates the ends of the auxiliary element from the fusible element by a precise gap. Upon low fault currents, as the fusible element vaporizes across the arc gap, the fusible element opens and arcs across the opening portion and across the gaps of the auxiliary element gap electrodes, thereby distributing the current across the fusible element arc gap and the two gaps at the gap electrodes.

With these high voltage, high amperage current limiting fuses it has been found that when intermediate current faults occur, that is, faults that cause melting in from about 1 to 100 seconds, interrupting problems

sometimes occur. These problems appear to occur because the high amperage arc exists for a duration long enough to cause ionized gas blow out from the fulgurite regions of sufficient magnitude to contact adjacent sections of the fusible element and thereby cause internal flashovers. With this invention this problem is substantially solved by providing a heat resistant barrier extended radially outwardly from and helically wound around the spider between the adjacent portions of the helically wound fusible element. This barrier provides a low conductivity insulating path extending into the filler particles that significantly limits such flashover between the adjacent portions of the fusible element. In addition, since the barrier is attached to the spider with a temperature resistant, insulating adhesive, the auxiliary element near the low current interrupting area is imbedded in the adhesive, thereby suppressing arc-over that can occur between the fusible element and the auxiliary element.

Other objects and advantages of this invention will be apparent from the following detailed description.

FIG. 1 is a segmented sectional side view of a current limiting fuse embodying this invention;

FIG. 2 is a view taken along lines 2—2 of FIG. 1; and

FIG. 3 is a partial sectional view of a portion of FIG. 1.

Referring to the drawing, a tubular enclosing casing **11** for a current limiting fuse **10** is constructed of suitable insulating material, such as glass fiber impregnated with epoxy resin. End pieces **13** and **14** are secured at the ends of casing **11** by any known means. A terminal means for connecting the fuse into an electrical circuit comprises electrical connecting terminals **16** and **17** that are adapted to make electrical contact with the circuit to be protected by fuse **10.** A fusible element **20,** which may be made of several ribbons depending on fuse rating, has two parallelly connected ribbons **20A** and **20B.** Element **20** is connected at its ends to connecting terminals **16** and **17** through connecting tabs **22** and **23,** respectively, and is helically wound around a longitudinally extending insulating core, or spider **25,** that is centrally, axially positioned within casing **10.** A filler **12** fills the space within the fuse casing and substantially surrounds the spider and the fusible element. Filler **12** may be any known satisfactory material, such as sand or finely divided quartz, that will provide regions for dissipating any arcs formed.

Spider **25** is of a generally star-shaped cross-section having a plurality of radially protruding, peripherally spaced apart, longitudinally extending fins **25A, 25B, 25C** and **25D.** Each of the fins has an outermost circumference forming shoulders **26,** a plurality of depressions of one depth forming shoulders **27** and of another depth forming shoulders **28.** Spider **25** is preferably of electrical insulating material adapted to evolve gas in the presence of an arc, and also having sufficient mechanical strength to be self-supporting and capable of withstanding temperatures for recognized periods of time in a manner known in the art.

A radially outwardly extending barrier **40** is helically wound around spider **25** and is positioned between adjacent portions of main element **20.** Barrier **40** is of an electrically insulating, high temperature resistant material that may be wound helically on the spider and is comprised of segmented portions, **40A** and **40B,** for example, as shown in FIG. **2,** and is attached to the spider by a suitable electrically insulating, high temperature resistant adhesive **38.**

To enable reliable interruption when a high level fault occurs, ribbons **20A** and **20B** have a plurality of circular perforations, or holes, **19** spaced apart along the length of the fusible elements to form portions of reduced cross-sectional area. At high current faults the fusible element rapidly vaporizes to interrupt the current.

For operation at low fault currents, beads **21** of low melting temperature alloy, such an tin-alloyed solder, are placed in intimate contact with main elements **20,** preferably near the midpoint of the main fusible element. At low current faults continuing for sufficient periods of time, fusible element **20** becomes hot enough to melt the alloy beads **21** and the amalgamation of the silver and alloy causes a hot spot with high enough resistance to melt the element ribbons **20A** and **20B** at these points. This effect, known as "M" effect, allows the fusible elements to melt at a temperature in a lower range than compared to the high melting temperature of pure silver for the fusible element. At high current faults the alloy elements have little or no effect since the elements vaporize at the fusion temperature for the silver.

To assist interruption at low fault currents, an auxiliary fusible conducting element **30** is helically wound on shoulders **27** and **28,** as shown, of spider **25** and is spaced apart from element **20.** Auxiliary element **30** is shown as comprising two wires, but more wires are used when required, which may be bare or insulated copper or silver, spaced apart from main element **20** and electrically connected at its respective ends by any suitable means to respective metallic clip or arc gap electrodes **33** and **34,** each of which is positioned on shoulder **26** of spider **25.** Arc gap electrodes **33** and **34** are located and positioned to be adjacent main element **20** but are separated from element **20** by any suitable means such as a porous fiberglass member **36** so as to provide a precisely controlled arc gap distance.

Auxiliary element **30** is preferably selected to have a minimum melt current approximately one-fourth that of main element **20,** and consequently several half-cycles are required to vaporize auxiliary element **30** on a relatively low fault current. During the time required to melt the auxiliary element arcing continues at the gaps of gap electrodes **33** and **34.** Thus, at low overcurrent levels the arcing energy is dissipated in three regions rather than at a single region, thereby assisting current interruption at small overload currents.

When low fault currents are occurring, flashovers are occasionally possible in this M region. To provide for maximum assurance against this occurring, auxiliary element **30** is separated from main element **20** and may be insulated with spaghetti insulation (not shown) or by imbedding in an insulating adhesive material **38,** as shown in FIG. 3.

When intermediate fault currents occur, the arc may cause ionized gas blow-out from the fulgurite regions across to adjacent sections of the fusible element, thereby producing flashovers. Insulating helical barrier **40** extends radially outwardly from the spider a distance selected to substantially prevent this flashover. Barrier **40** may be made of any insulating, high temperature resistant material, but it has been found that mica, of several layers, of a thickness between 0.025 and 0.0625 provides the desired amount of barrier insulation. A mica barrier, because of its relative inflexibility, is cut into portions, such as portions **40A** and **40B,** which are mounted to overlap each other at the cut portions, as best seen in FIG. **2,** so as to provide a continual helical barrier between the adjacent fusible main elements. Other material may be used with apparent requisites that it be a high temperature resistant material that will block hot gases and be sufficiently flexible to permit placing it on the spider accurately and simply. The high temperature resistant adhesive may be any type suitable as, for example, adhesive of the type sold under trademark "Sauereisen No. 1."

I claim:

1. A high voltage current limiting fuse comprising:
a casing,
terminal means for connecting the fuse into an electrical circuit,
a longitudinally extending spider,
a main fusible element connected to the terminal means and helically wound around the spider,
a radially outwardly extending barrier helically wound around the spider to form a helical barrier between adjacent portions of the fusible element, and
a filler surrounding at least part of the main element selected to provide regions for dissipating arcs formed within the fuse.

2. A high voltage current limiting fuse according to claim **1** wherein said barrier comprises a helically wound mica sheet.

3. A high voltage current limiting fuse according to claim **2** wherein said mica sheet has a thickness of approximately 0.025 to 0.0625 inches.

4. A high voltage current limiting fuse according to claim **1** wherein said barrier comprises a plurality of mica sheet sections arranged along the helical path and positioned to overlap each other.

5. A high voltage current limiting fuse according to claim **4** wherein said mica sheet sections comprise a plurality of layers of mica.

6. A high voltage current limiting fuse according to claim **1** wherein said barrier comprises a plurality of layers of mica.

7. A high voltage current limiting fuse according to claim **6** wherein said plurality of layers of mica have a thickness of approximately 0.025 to 0.0625 inches.

8. A high voltage current limiting fuse comprising:
a casing,
electrical connecting terminals adapted to connect the fuse into an electrical circuit,
a spider extending longitudinally within the casing,
a main fusible element connected to the electrical connecting terminals and helically wound around the spider,
a radially outwardly extending barrier helically wound around the spider and to form a helical barrier between adjacent portions of the fusible element, and
a filler within the casing selected to provide regions for dissipating arcs formed within said casing.

9. A high voltage current limiting fuse according to claim **8** wherein said barrier is composed of a high temperature resistant, electrically insulating material.

10. A high voltage current limiting fuse according to claim **9** wherein said barrier comprises a plurality of sections arranged along the helical path and positioned to overlap each other.

11. A high voltage current limiting fuse according to claim 8 wherein said barrier comprises a mica sheet having a thickness of approximately 0.025 to 0.0625 inches.

12. A high voltage current limiting fuse according to claim 8 also comprising an auxiliary conductive element helically wound along a portion of the spider and having gap electrodes at each end spaced apart from the main fusible element by a distance selected to provide a selected arc gap.

13. A high voltage current limiting fuse according to claim 12 also comprising a high temperature resistant, electrical insulating adhesive applied to the barrier and the spider to attach said barrier to said spider.

14. A high voltage current limiting fuse according to claim 13 wherein said auxiliary element is imbedded in the adhesive along a portion of its length.

15. A high voltage current limiting fuse comprising:

a tubular casing,

electrical connecting terminals adapted to connect

the fuse in an electrical circuit,

a spider extending longitudinally within the casing,

a main fusible element having ends electrically connected to the respective connecting terminals and helically wound around the spider,

an auxiliary conductive element helically wound over a portion of said spider and spaced apart from the main fusible element, said element having electrodes at each end spaced apart by a selected amount from said main fusible element to provide an arc gap between said main fusible element and said auxiliary element,

a radially outwardly extending barrier helically wound around the spider extending to form a helical barrier between adjacent portions of the main fusible element, and

a filler within said tubular casing selected to provide arc energy dissipation areas within the fuse.

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