# United States Patent [19]

**Kozacka**

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[45] **Oct. 22, 1974**


[54] **HIGH-VOLTAGE FUSE**


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

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



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[52] **U.S. Cl.** ..... **337/158**, 337/161, 337/276

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

[58] **Field of Search** ..... 337/158, 159, 160, 161, 337/275, 276



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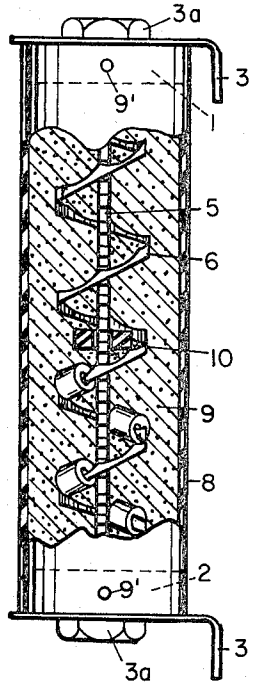
*Primary Examiner*—James D. Trammell
*Assistant Examiner*—Fred E. Bell
*Attorney, Agent, or Firm*—Erwin Salzer



[57] **ABSTRACT**

A high-voltage fuse having a helically wound fusible element includes a pair of supports for the latter supporting each turn of the fusible element encompassing 360 degrees at only one or two points, the sections of the fusible element situated between these two points being supported only by the pulverulent arcquenching filler surrounding the fusible element.


**6 Claims, 3 Drawing Figures**



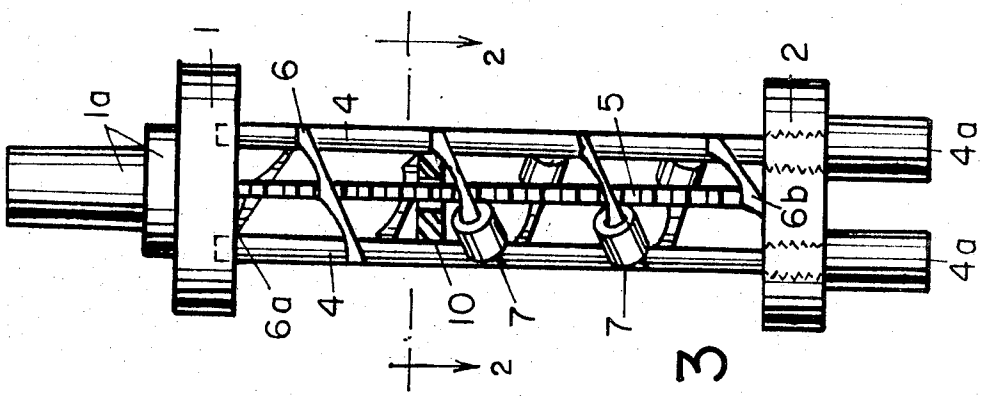



FIG. 3

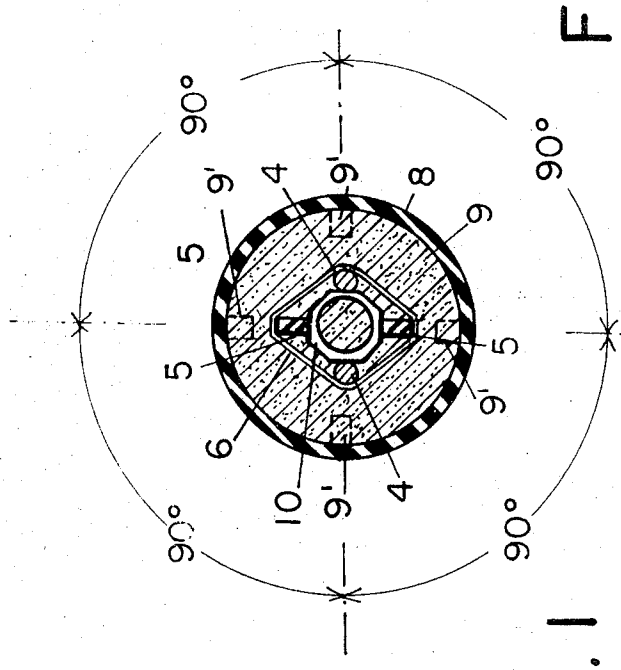



FIG. 2

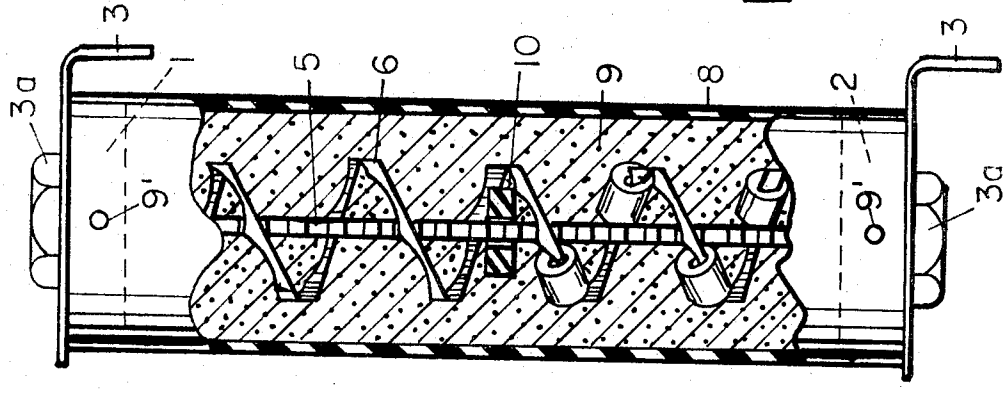



FIG. 1

# HIGH-VOLTAGE FUSE

## BACKGROUND OF THE INVENTION

In the classic design of high-voltage fuses having helically wound fusible elements the latter are supported by mandrels of insulating material which are substantially star-shaped in cross-section. Such mandrels are very expensive if made of high-grade ceramic materials, and tend to become more or less conductive by metal vapors condensing on the surfaces thereof, thus exhibiting a tendency of tracking.

There has been a trend toward evolving supports for helically wound fusible elements of high-voltage fuses which are less expensive than those made of high-grade ceramic materials. In addition thereto there has been a trend toward fusible element supports not subject to the limitations and drawbacks of fusible-element-supporting mandrels which are star-shaped in cross-section. U.S. Pat. No. 3,599,138 to Frederick J. Kozacka, Aug. 10, 1971 for HIGH-VOLTAGE FUSE discloses a high-voltage fuse having supporting means for the fusible element which fuse is an outgrowth of the aforementioned trends. This fuse includes four narrow strips of an electric insulating material rectangular in cross-section angularly displaced 90 degrees. The radially outer edges of these four strips form the edges of a prismatic surface. The fusible element is wound helically around the aforementioned edges of these four strips and is, therefore, situated in the aforementioned prismatic surface.

The patent application of Erwin Salzer, filed 7/9/71, Ser. No. 161,080 for METHOD OF ASSEMBLING HIGH-VOLTAGE FUSES AND SUBASSEMBLY THEREFOR discloses a method of assembling fuses wherein all supports of the helically wound fusible elements between the ends thereof are dispensed with except the for pulverulent fillers by which the elements are surrounded.

The aforementioned method includes the steps of

a. inserting a plurality of rods into axial bores in one of a pair of plug terminals and causing the ends of said plurality of rods remote from one of said pair of plug terminals to engage corresponding axial bores in the other of said pair of plug terminals while maintaining said pair of plug terminals in coaxial relation;

b. winding at least one fusible element substantially helically around said plurality of rods and conductively connecting the ends of said fusible element to the axially inner end surfaces of said pair of plug terminals;

c. fitting said pair of plug terminals and said plurality of rods jointly into a tubular insulating casing and affixing said casing to said pair of plug terminals;

d. filling said casing with a pulverulent arc-quenching filler through a bore in said one of said pair of plug terminals and withdrawing said plurality of rods 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.

While this process normally results in fuses having no other support for the helically wound fusible element



or elements thereof than the surrounding pulverulent arc-quenching filler, the invention is predicated on the concept that this process may not only be used to assemble fuses which dispense completely with a mandrel-like support for the fusible element, but applied to manufacture fuses having a support which would be incapable of supporting a helically wound fusible element unless the above process were used for their assembly. While the presence of any support capable of supporting a fusible element helically wound thereon is always undesirable, or while the drawbacks of such supports generally carry more weight than the desirable features thereof, the presence of greatly simplified supports may be desirable, not so much for their supporting function, but for auxiliary function which such supports may perform, e.g. evolving flows of an arc-extinguishing gas.

## SUMMARY OF THE INVENTION

The method of manufacturing high-voltage fuses according to this invention includes the steps of

a. arranging a pair of plug terminals in coaxial relation and spacing said pair of plug terminals by insulating strip means and by a plurality of metal rods arranged parallel to the axis of said pair of plug terminals and extending through bores in one of said pair of plug terminals to the outer surface thereof;

b. winding fusible element means helically around said insulating strip means and said plurality of metal rods so as to be located on the surface of a prism whose edges are defined by said insulating strip means and said plurality of metal rods, and thereafter conductively connecting the ends of said fusible element means to said pair of plug terminals;

c. inserting the structure formed by said pair of plug terminals, said insulating strip means, said plurality of metal rods and said fusible element means into a tubular casing of insulating material and affixing said casing to said pair of plug terminals; and thereafter

d. filling said casing with a pulverulent arc-quenching filler through an aperture in one of said pair of plug terminals and gradually drawing said plurality of metal rods out of said casing while leaving said insulating strip means inside said casing.

A fuse manufactured according to the above process includes a tubular casing of electric insulating material, a pair of plug terminals closing the ends of said casing; a pulverulent arc-quenching filler inside said casing and helically wound fusible element means conductively interconnecting said pair of plug terminals and submersed in said filler. The turns of said fusible element means are arranged in the lateral surfaces of a prism having a predetermined number of edges. Insulating strip means supported on the ends thereof by said pair of plug terminals support each of the turns of said fusible element at a number of points smaller than the number of lateral surfaces of said prism.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is substantially a front view of a high-voltage fuse embodying the present invention with a portion of the fuse broken away;

FIG. 2 is a section along 2—2 of FIG. 3; and

FIG. 3 is a sub-assembly of the structure of FIG. 1.

## DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, the process of making a fuse embodying the present invention starts by arranging a pair of plug terminals **1,2** in coaxial relation as shown in FIG. **3.** Plug terminal **1** is provided with an extension **1***a*. This extension may be used as a connector when the fuse is fully assembled, in which case extension **1***a* forms an integral part of plug terminal **1.** If it is intended to manufacture fuses having terminal strips **3** abutting against the axially outer end surfaces of plug terminals **1,2** extension **1***a* may either be deleted, or removably attached to plug terminal **1** as, for instance, by screw-threads. In the fuse shown in FIG. **1** terminal strips **3** are affixed by means of hex-screws **3***a* to the axially outer end surfaces of plug terminals **1,2.** In the drawings reference numeral **4** has been applied to indicate a pair of metal rods and reference numeral **5** has been applied to indicate a pair of strips of insulating material, e.g. glass-cloth-melamine. The surfaces of metal rods **4** are smooth, or polished. The radially outer surfaces of insulating strips **5** are toothed, or provided with corrugations intended to be engaged by a fusible element **6** in ribbon form. The geometry of fusible element **6** may conform to that disclosed more in detail in U.S. Pat. No. 3,743,994 to Frederick J. Kozacka, July 3, 1973 for RIBBON-TYPE FUSIBLE ELEMENT FOR HIGH-VOLTAGE FUSES AND FUSE INCLUDING THE ELEMENT. Fusible element **6** may be provided with beads **7** of the kind more fully disclosed in the aforementioned Kozacka patent, and for the purpose disclosed in that patent. The upper ends of rods **4** and insulating strips **5** are inserted into blind holes provided in the axially inner end surface of plug terminal **1** and coextensive with said ends. The lower ends of insulating strips **5** are inserted into blind holes provided in the axially inner end surface of plug terminal **2.** Rods **4** are screw-threaded at the portions thereof which project transversely through terminal plug **2** and the screw-threaded portions thereof engage screw threads in bores in plug terminal **2** which extend from one end surface to the other end surface thereof. The axially outer ends **4***a* of rods **4** are of increased diameter to allow more convenient handling of rods **4.** To be more specific, the ends **4***a* of rods **4** of increased diameter make it conveniently possible to screw rods **4** through plug terminal **2** and to insert the ends of rods **4** remote from plug terminal **2** into the blind holes in plug terminal **1** intended to receive these ends. It will be apparent from FIG. **3** that rods **4** and insulating strips **5** are arranged parallel to the common axis of plug terminals **1,2** when parts **1,2,4** and **5** are combined to form a substantially squirrel-cage-shaped subassembly.

After parts **1,2,4** and **5** have been combined as set forth above, fusible element **6** is wound helically around rods **4** and strips **5** so as to be located on the surface of a prism whose cages are defined by rods **4** and strips **5.** In the instant case this prism has four edges and four lateral surfaces. The number of edges and lateral surfaces might be reduced to three, or increased to exceed four. After fusible element **6** has been wound helically around parts **4,5,** the ends of fusible element **6** are conductively connected at **6***a*, **6***b* to the pair of plug terminals **1,2.** This may be achieved as shown more in detail in U.S. Pat. No. 3,571,775 to Frederick J. Kozacka et al, Mar. 23, 1971 for HIGH-VOLTAGE FUSE HAVING A PLURALITY OF HELICALLY WOUND RIBBON FUSE LINKS.

The assembly steps described heretofore result in a structure including parts **1,2,4,5** and **6** and will include beads **7** if it is intended to use the same which is optional, not mandatory. The subassembly **1,2,4,5,6** is then inserted into a tubular casing **8** of insulating material, e.g. melamine-glass-cloth. The inner diameter of casing **8** is equal to the outer diameter of plug terminals **1,2** as a result of which parts **1,2** and **8** are in coaxial relation when fitted together. Thereupon casing **8** is affixed to plug terminals **1,2,** e.g. by driving steel pins **9'** through aligned bores in casing **8** and plug terminals **1,2** as indicated in FIGS. **1** and **2.**

Thereupon casing **8** is filled with a pulverulent arc-quenching filler **9,** e.g. quartz-sand. To this end plug terminal **2** is preferably provided with a bore (not shown in the drawings) in the center thereof. If the arc-quenching filler is filled into casing **8** through a bore in plug terminal **2,** the structure shown in FIG. **3** is inverted during the filling operation. Rods **4** are withdrawn during the filling operation or at the end of that operation. The strips **5** of insulating material are left in position inside of casing **8** in engagement with fusible element **6** and with plug terminals **1,2.** The withdrawal of rods **4** must be effected gradually in axial direction upon unscrewing rods **4** from plug terminal **2.** The withdrawal of rods **4** from fusible element can be effected when the latter is sufficiently supported by the arc-quenching filler **9** and must be limited at any point of time to sections of the fusible element which are sufficiently supported by surrounding arc-quenching filler. It is possible, for instance, to withdraw rods **4** gradually while the level of the arc-quenching filler **9** in casing **8** is gradually rising, in which instance casing **8** should be tapped during the filling and rod-removal operation to cause timely settling of the arc-quenching filler.

For additional information in regard to the assembly process which has been described above reference may be had to the copending patent application of Erwin Salzer which has been fully identified above.

It is desirable, though not absolutely necessary, to arrange a bracing ring **10** inside of rods **4** and strips **5.** Bracing ring **10** is arranged at some point intermediate plug terminals **1,2,** preferably midway between plug terminals **1,2.** Ring **10** precludes bending of rods **4** and strips **5** in radially inward direction under the pressure exerted by fusible element **6** upon these two parts **4,5.** It will be apparent from FIG. **1** that bracing ring **10** remains inside of casing **8** upon removal of rods **4** therefrom and continues to form an effective brace for parts **5.**

It will be apparent from FIG. **3** that when spacing plug terminals **1, 2** by parts **4,5,** parts **4** are arranged in a first common plane and parts **5** are arranged in a second common plane at right angles to said first common plane. The radial spacing of each of parts **4** and **5** from the axis of plug terminals **1,2** is preferably equal, as a result of which the winding formed by fusible element **6** forms a square when seen in top-plan view as in FIG. **2.**

Strips **5** give some support to fusible winding **6,** through such support may be dispensed with entirely, as shown in the above referred-to patent application of Erwin Salzer. Even if there is no need whatever for a support for fusible element **6** other than the surrounding pulverulent filler **9,** supporting strips **5** may be de-

sirable because they may function as arc-quenchers when made of a synthetic resin evolving arc-quenching gases when exposed to the action of electric arcs. One or two strips 5 of gas-evolving material are relatively effective arc-quenchers, but are much less expensive than conventional supporting mandrels for helically wound fusible elements, and have much smaller surfaces on which metal vapors may condense, resulting in tracking. For the same reason fuses embodying the present invention are also preferable to the plate structure for supporting helically wound fusible elements shown in Kozacka U.S. Pat. No. 3,599,138 referred-to above.

As mentioned above, the number of strips 5 must not necessarily be two, but may be reduced to one, wherever desirable. This does not significantly affect the process of assembly which has been described above. It calls merely for the provision of three metal rods 4 instead of two, the third rod 4 taking the place of one of the two strips 5.

If N is the number of the edges of a prism defined by the radially outer edges of strips 5 and by rods 4, and is also the number of the lateral sides of the prismatic surface in which the helically wound fusible element 6 is arranged, and if n is the number of points at which each of the turns of the fusible element is supported by a strip means 5, then the inequality

$N > n$

obtains for all fuses embodying the present invention.

In the structure illustrated in FIGS. 1-3, the number $N=4$ and the number $n=2$. In words, insulating strip means 5 support each turn of the helically wound fusible element 6 at only two points angularly displaced 180°. The portions of the turns of helically wound fusible element 6 situated between the aforementioned two points of support by strips 5 are supported by arc-quenching filler 9 only in the absence of additional supporting means for said portions.

The structure illustrated in FIGS. 1–3 could be modified by making $N=4$ and $n=1$, i.e. eliminating one of insulating strips 5.

In fuses including one single helically wound fusible element, supporting strips 5 are never required for support reasons, but may be desirable to evolve arc-quenching gases at predetermined points of the fusible element. The larger the number of helically wound fusible elements conductively interconnecting the plug terminals of a fuse, the more critical is the spacing between contiguous turns of the fusible element, and under such conditions it may be desirable to provide a fuse with one or two supporting strips for the fusible element even though the aspect of evolution of arc-quenching gases may be of no import in the particular instance.

It will also be apparent that minimizing the surface of supports 5 reduces the danger of tracking to a lower level than in any prior art fuse having a support structure for its helically wound fusible element.

I claim as my invention:

1. A high-voltage fuse including

a a tubular casing of electric insulating material;

b a pair of terminal plugs closing the ends of said casing;

c a pulverulent arc-quenching filler inside said casing;

d helically wound fusible element means conductively interconnecting said pair of terminal plugs and submersed in said filler, the turns of said fusible element means being arranged in the lateral surfaces of a prism having a predetermined number of edges; and

e insulating strip means supported on the ends thereof by said pair of terminal plugs and supporting each of the turns of said fusible element at a number of points smaller than said predetermined number.

2. A high-voltage fuse as specified in claim 1 wherein said insulating strip means are of a synthetic resin evolving gas under the action of electric arcs.

3. A high-voltage fuse as specified in claim 1 wherein the turns of said fusible element means are arranged in the lateral surfaces of a prism having four edges and wherein said insulating strip means support each turn of said fusible element means at only two points angularly displaced 180°.

4. An electric high-voltage fuse including

a. a tubular casing of electric insulating material;

b. a pair of terminal elements closing the ends of said casing;

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

d. a pair of strip-shaped fusible element supports of electric insulating material supported by said pair of terminal elements, said pair of fusible element supports being arranged parallel to and in spaced relation from the axis of said casing; and

c. a helically wound fusible element arranged in the lateral surfaces of a four sided prism, each of the turns of said fusible element being supported by said pair of fusible element supports at two points only, the portions of each said turns situated between said two points being supported by said arc-quenching filler only in the absence of additional supporting means for said portions.

5. A sub-assembly for manufacturing high-voltage fuses including

a. a pair of spaced coaxially arranged plug terminals;

b. a plurality of rods projecting from the axially outer end surface of one of said pair of plug terminals transversely through said one of said pair of plug terminals into blind holes in the axially inner end surface of the other of said pair of plug terminals;

c. a strip of electric insulating material arranged in parallel relation to said plurality of rods and having axially outer ends projecting into recesses in the axially inner end surfaces of said pair of plug terminals; and

d. a fusible element wound helically around said plurality of rods and said strip of electric insulating material and conductively connected with the ends thereof to said pair of plug terminals.

6. A sub-assembly for manufacturing high-voltage fuses including

a. a pair of spaced coaxially arranged terminal plugs;

b. a pair of strip-shaped fusible element supports of electric insulating material arranged parallel to and in spaced relation from the axis of said pair of terminal plugs at opposite sides of said axis and having axially outer ends projecting into blind recesses in

the axially inner end surfaces of said pair of terminal plugs;

c. a pair of metal rods arranged parallel to and in spaced relation from said axis of said pair of terminal plugs at opposite sides of said axis and angularly displaced 90° relative to said pair of fusible element supports, each of said pair of metal rods projecting from the axially outer surface of one of said pair of terminal plugs transversely through said one of said pair of terminal plugs into blind holes in the axially inner end surface of the other of said pair of terminal plugs.

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