ELECTRIC FUSES HAVING RIBBON LINKS IN RADIAL PLANES

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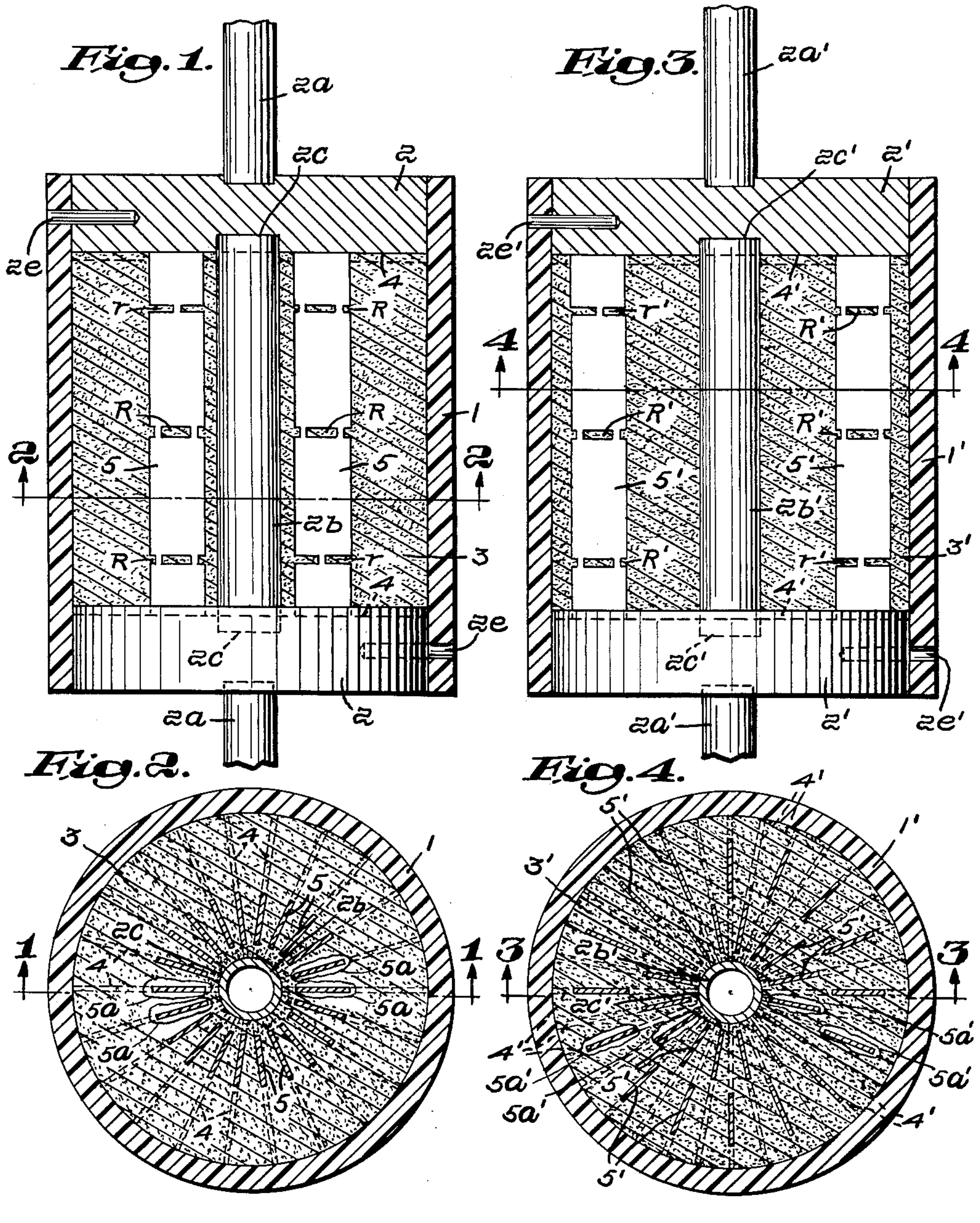

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ELECTRIC FUSES HAVING RIBBON LINKS IN RADIAL PLANES

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This invention is concerned with electric fuses for the protection of electric circuits and the protection of the insulation thereof, and also for the protection of electric machinery and the protection of electric apparatus.

From a more limited point of view this invention is concerned with electric fuses capable of generating arc voltages which are relatively high in comparison to the system voltage, and capable of generating such arc voltage so rapidly as to preclude any fault current from ever reaching the available current peak which the system is capable of producing. Such fuses are generally known as, and referred to by the generic term, current-limiting fuses, or CLF, in abbreviated form. A current-limiting fuse generally comprises a pulverulent arc-quenching filler such as, for instance, chemically reasonably pure quartz sand. Arc-quenching fillers such as quartz sand which have a high heat absorbing capacity on account of their high heat of fusion form so-called fulgurites when exposed to the heat of the electric arc formed in the fuse incident to blowing thereof. A fulgurite consists of particles which are fused or sintered together and adhere more or less firmly to each other and form a more or less dense structure in the nature of a conglomerate. Such a body or fulgurite is a good conductor of electricity as long as hot, and becomes a poor conductor of electricity or a good insulator as it cools down. Hot fulgurites tend to form a conductive path from one terminal of a fuse to the other, and thus tend to defeat the very purpose of the fuse, i.e., interposing insulation into the circuit to bring the current flowing therein down to zero.

It is, therefore, a general object of this invention to provide fuses having a fulgurite-forming arc-qenching filler wherein the fulgurites formed by fusion of the filler have but little tendency of establishing a current path of low resistance between one terminal of the fuse and the other.

In fuses having a large current-carrying capacity generally a plurality of fusible elements or fuse links are arranged in a common casing or fuse tube. There are various ways of arranging a plurality of fuse links in a common fuse tube or casing. A preferred arrangement is to arrange each link in a radial plane of the casing or fuse tube. In such a fuse there is, however, a tendency of merger of the fulgurites formed upon blowing of which one is associated with each of the radial fusible elements or fuse links. Such a merger results in the formation of a relatively large more or less unitary and dense fulgurite in the form of a toroid which is coaxial with the fuse tube or casing. A fulgurite of this nature and configuration tends to establish a conductive connection between the terminals of the fuse and to have a particularly small resistance as long as it is hot, and thus tends to defeat the very purpose of the fuse.

It is, therefore, a special object of this invention to provide electric fuses having a pulverulent arc-quenching filler of the fulgurite-forming type as, for instance, quartz sand, and comprising fusible elements or fuse links in form of ribbons arranged in radial planes, in which fuses the danger resulting from merger of the fulgurites of which each is associated with one of the fusible elements or fuse links is minimized, or completely eliminated.

These and other objects and advantages of the invention will become more apparent from the following description of a preferred embodiment thereof, when taken in connection with the accompanying drawings, in which:

Fig. 1 is a section along **1—1** of Fig. 2 and shows a widely used prior art fuse structure;

Fig. 2 is a section along **2—2** of Fig. 1;

Fig. 3 is a section along **3—3** of Fig. 4 and shows a preferred embodiment of this invention; and

Fig. 4 is a section along **4—4** of Fig. 3.

Referring now to the drawings, and more particularly Figs. 1 and 2 thereof, numeral **1** has been applied to indicate a fuse tube or casing made of a suitable heat-shock resistant insulating material as, for instance, a glass-fiber-cloth-synthetic-resin laminate. Casing **1** is closed on both ends thereof by identical terminal elements or plugs **2** and filled with a pulverulent arc-quenching filler **3**, e.g. quartz sand. Plugs **2** are held in position by transverse steel pins **2*e***. Blade contacts **2*a*** are intended for insertion of the fuse into a fuse holder. They form integral parts of terminal elements on plugs **2**. The tubular spacing member **2*b*** for parts **2** is inserted with the ends thereof into coaxial recesses **2*c*** in parts **2**. The axially inner surface of each plug or terminal element **2** is provided with a system of radial grooves **4** of which contiguous grooves enclose equal angles α. The fuse further comprises a plurality of fuse links or fusible elements in ribbon-form to which reference numeral **5** has been applied. Fusible elements or fuse links **5** are preferably made of sheet silver. The axially outer ends of each fuse link **5** are inserted into a pair of juxtaposed registering grooves **4** and are conductively connected to terminal elements or terminal plugs **2** by means of solder joints (not shown). The distance of each fuse link **5** from the axis of casing **1** is much less than the distance between each fuse link **5** from the axis of casing **1** is much less than the distance between each link and the inner surface of the casing **1**. The reason underlying this particular geometry resides in the fact that the electromagnetic field which prevails in the fuse structure tends to drive the arcs which are formed incident to blowing of the fuse radially outwardly. The same is true in regard to the ionized products of arcing. Hence only the radially outer portions of the quartz sand inside of casing **1** are effectively used as heat absorber and arc-quencher, whereas the radially inner portions of the quartz sand, i.e. the portions radially inwardly from the radially inner edges of the fuse links **5**, are hardly utilized during the interrupting process as arc quenchers and heat absorbers.

The outlines **5*a*** in Fig. 2 indicate the cross-section of the fulgurites which form under normal interrupting conditions. Under more severe interrupting conditions the fulgurites are larger, and when the fulgurites become larger they tend to merge and to form a more or less unitary fulgurite substantially in the shape of a toroid providing, as long as hot, a current path of very small resistance between the terminal elements or plugs **1**.

If the width of each link **5** is designated by w, and the thickness of each link is designated by s, then the cross-section area of each link is $w \times s$, and the total cross-sectional area of all the links **5** is equal to the total number of links times $w \times s$. The terms width and cross-sectional area, as used in this context, refer to points of the links where their width and cross-sectional area are not reduced. As will be apparent from Fig. 1 each link **5** comprises several points of reduced width and reduced cross-sectional area or reduced cross-section. Arcs are intiated at these points at the occurrence of any fault current in the circuit to be protected by the fuse. In the particular case illustrated in Fig. 1 each link 5 has three points of reduced width and of reduced cross-section, namely two points R where the cross-section is reduced but not as much as at the point r which latter point is the point of minimum cross-sectional area. The points r of minimum cross-sectional area or minimum cross-section will always fuse before the points R, since the former call for a smaller $\int i^2dt$ to fuse than the latter. Because the points r are those where an arc is initially kindled, arc duration is longest at the points r. Hence there is a tendency of fulgurites to grow relatively wide adjacent to points r. Contiguous fusible elements 5 are arranged to have point r of minimum cross-section at opposite ends thereof, thus tending to avoid merger of contiguous fulgurites adjacent to points r where links 5 have their smallest cross-section.

Referring now to Figs. 3 and 4, in these figures the same reference characters as in Figs. 1 and 2 with a prime sign added have been applied to indicate like parts. Thus casing 1′ is closed by plugs 2′ on both sides. Plugs 2′ are held in position by pins 2e′. Spacer 2b′ is inserted into recesses 2c′ in plugs 2′. Plugs 2′ are provided with blade contacts 2a′ and with radial grooves 4′ receiving the ends of ribbon-type fuse links 5′. The latter are immersed in a pulverulent fulgurite-forming arc quenching filler 3′ such as, for instance, quartz sand. The angle enclosed between contiguous links 5′ and contiguous grooves 4′ is $\alpha/2$. The cross-sectional area of each link 5′ is in the order of, but slightly less than,

$$\frac{w \times s}{2}$$

wherein w has the same meaning as explained in connection with Figs. 1 and 2 and $s/2$ is the thickness of the fuse links.

In the structure of Figs. 3 and 4 the total number of grooves 4′ and the total number of fuse links 5 is twice as large as in the structure of Figs. 1 and 2. The total cross-sectional area of all the fuse links in Figs. 3 and 4 is slightly less than in Figs. 1 and 2. The structures of Figs. 1 and 2, on the one hand, and of Figs. 3 and 4, on the other hand, are designed to have the same current-carrying capacity or current rating, and their fuse links, substantially identical in regard to geometry, should have about the same total cross-sectional area. Because the number of fuse links is larger in the structure of Figs. 3 and 4 than in the structure of Figs. 1 and 2 and the heat exchange area in the former larger than in the latter, the total cross-sectional area of the fuse links may be smaller in the former than in the latter if both are to have the same current-carrying capacity, or current rating.

It will be apparent from Fig. 4 that the fusible elements 5′ are arranged in radially staggered relation which greatly reduces the danger of merger of contiguous fulgurites 5a′ in spite of the fact that the angular spacing or displacement of contiguous fusible elements 5′ has been reduced 50% in comparison to that of Figs. 1 and 2.

The fuse links 5′ of the structure of Figs. 3 and 4 have points of reduced cross-section analogous to those described in connection with Figs. 1 and 2, namely the points R′ of relatively moderately reduced cross-section and the points r' of drastically reduced cross-section, or minimum cross-section. Contiguous fusible elements 5′ are arranged to have said point r' of minimum cross-section at opposite ends thereof. Thus the structure of Figs. 3 and 4 combines two important features tending to avoid merger of hot fulgurites, namely the arrangement of points r of minimum cross-section of contiguous fusible elements 5′ on opposite ends thereof, and the arrangement of contiguous elements 5′ in radially staggered relation.

In the structure shown in Figs. 1 and 2 the total number of link-receiving grooves 4 and the total number of links 5 is 12, whereas in the embodiment of the invention shown in Figs. 3 and 4 the total number of link-receiving grooves 4′ and the total number of links 5′ is 24. The total number of fusible elements or fuse links should be an even number 2N, N being any whole number. N fuse links or fusible elements 5′ are arranged in radial equiangularly spaced planes of casing 1′ and form a radially inner shell, and N fuse links or fusible elements 5′ are arranged in radial equiangularly spaced planes of casing 1′ and form a radially outer shell angularly displaced by $\alpha/2$ deg. with respect to said radially inner shell.

In other words, the radially inner shell forms a first system of fuse links 5′ whose distance from the axis of casing 1′ is relatively small and whose individual links are angularly spaced $360/n$ degrees. The radially outer shell forms a second system of fuse links 5′ whose distance from the axis of casing 1 is relatively large and whose individual links are angularly spaced $360/n$ degrees. The gaps formed between contiguous fusible elements forming the aforementioned first system of fusible elements and the gaps formed between contiguous fusible elements forming the second system of fusible elements contain but pulverulent arc quenching filler and are free from any metal parts.

Although this invention has been described in considerable detail, it is to be understood that such description of the invention is intended to be illustrative rather than limiting, as the invention may be variously embodied, and is to be interpreted as claimed.

I claim as my invention:

1. An electric fuse comprising a tubular casing of insulating material; a pair of terminal elements one on each end of said casing closing said casing; a pulverulent fulgurite-forming arc-quenching filler inside said casing; fusible elements in ribbon-form immersed in said filler and conductively interconnecting said pair of terminal elements, the total number of said fusible elements being 2N and N being a whole number; N of said fusible elements being arranged in radial equiangularly spaced planes of said casing and forming a radially inner shell; and N of said fusible elements being arranged in equiangularly spaced planes of said casing and forming a radially outer shell angularly displaced with respect to said radially inner shell; and N being the same number any occurrence.

2. An electric fuse comprising a tubular casing of insulating material; a pair of metal plugs each closing one end of said casing; each of said pair of plugs having 2N radial grooves on the axially inner end surface thereof; a pulverulent quartz filler inside said casing; silver ribbons totalling the number 2N arranged in said casing, immersed in said filler and each inserted with the ends thereof in one of said grooves in each of said pair of plugs; N of said ribbons being arranged to form a radially inner shell and N of said ribbons being arranged to form a radially outer shell; N being the same whole number any occurrence.

3. An electric fuse comprising a tubular casing of insulating material and having a longitudinal axis; a pair of terminal elements one on each end of said casing closing said casing; a pulverulent fulgurite-forming arc-quenching filler inside said casing; a first system of fusible elements in ribbon-form immersed in said filler and conductively interconnecting said pair of terminal elements, the fusible elements forming said first system having a predetermined distance from said longitudinal axis and being arranged in radial planes of said casing, and contiguous elements forming said first system being angularly spaced $360/n$ degrees; a second system of fusible elements in ribbon-form immersed in said filler and conductively interconnecting said pair of terminal elements, the fusible elements forming said second system having a distance from said longitudinal axis exceeding said predetermined distance and being arranged in radial planes of said casing other than said radial planes wherein said

fusible elements forming said first system are arranged, and contiguous elements forming said second system being angularly spaced 360/n degrees; n being the same whole number both occurrences.

4. An electric fuse comprising a tubular casing of insulating material and having a longitudinal axis; a pair of terminal elements each on one end of said casing closing said casing; a pulverulent fulgurite-forming arc-quenching filler inside said casing; a first system of fusible elements in ribbon-form immersed in said filler and conductively interconnecting said pair of terminal elements, said fusible elements forming said first system having a predetermined spacing from said longitudinal axis of said casing and being arranged in radial equiangularly spaced planes of said casing and forming gaps therebetween containing but said filler and being free from any metal parts; a second system of fusible elements in ribbon-form immersed in said filler and conductively interconnecting said pair of terminal elements, said fusible elements forming said second system having a spacing from said longitudinal axis of said casing exceeding said predetermined spacing and being arranged in radial equiangularly spaced planes of said casing other than said radial planes wherein said fusible elements forming said first system are arranged, and said fusible elements forming said second system forming gaps therebetween containing but said filler and being free from any metal parts.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,982,835 May 2, 1961

Frederick J. Kozacka

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, lines 41 and 42, strike out "the distance between each fuse link 5 from the axis of casing 1 is much less than".

Signed and sealed this 19th day of September 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents

USCOMM-DC

UNITED STATES PATENT OFFICE
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