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2,157,906

ELECTRIC FUSE

Original Filed June 22, 1936

Fig. 1.

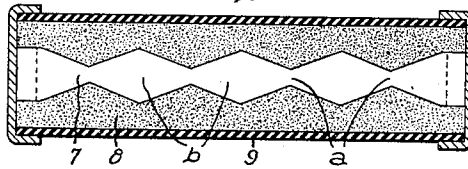


Fig. 2.

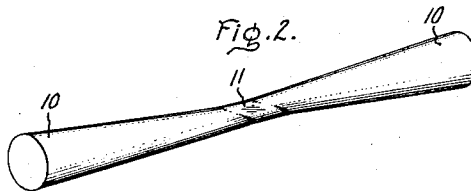


Fig. 3.

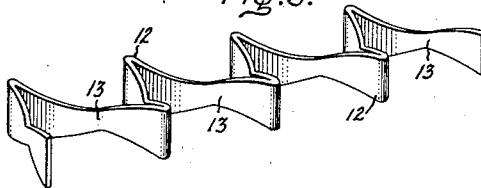


Fig. 4.

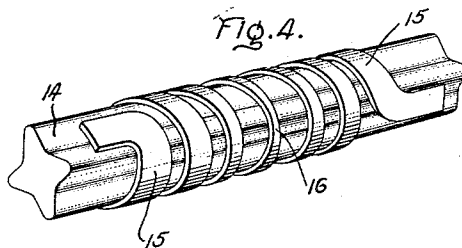


Fig. 5.

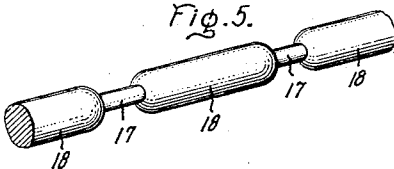
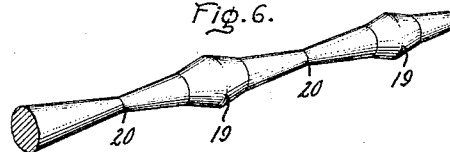


Fig. 6.



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UNITED STATES PATENT OFFICE

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ELECTRIC FUSE

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12 Claims. (Cl. 200—131)

The present invention relates to electric fuses and particularly to improvements in the construction of enclosed high voltage fuses of the current limiting type wherein the fusible conductor is embedded in an arc quenching material.

In my previous application, Serial No. 51,694, filed November 26, 1935 and assigned to the assignee of the present invention, there is disclosed an enclosed high voltage fuse having a fusible conductor which is embedded in pulverulent or sandy arc quenching material and designed to fuse and vaporize throughout substantially its entire length upon subjection of the conductor to excess current of predetermined magnitude, thereby to insert the required current limiting resistance into the high voltage current path. The fusible conductor is formed also with a cross section varying either continuously or in steps from a predetermined point up to or approximately up to the points of connection of the fusible conductor so that upon occurrence of a very large excess current, such as in the case of a large overload or short circuit, or even upon a medium overload, the dissipation of the conductor does not take place instantly over its whole length and consequently the interruption of the current flow is prevented from occurring so suddenly as to occasion undesirable excess voltages and violent stresses upon the electrical equipment connected in the circuit with the fuse. With fuses of this type, however, under some circumstances there may arise in case of a small overload current, the danger that the fusing and vaporizing function takes place jerkily or is effected too slowly, resulting in unsatisfactory fuse operation on such small overload.

An important object of the present invention is, therefore, the provision of improvements in fuses of the type disclosed in my above identified application, whereby the danger referred to in the preceding paragraph is avoided and efficiency and reliability of operation of the fuses are insured not only upon the occurrence of short circuits and very large or medium overloads but also upon the occurrence of only slight overloads.

In accordance with the present invention, a fuse is provided with one or more fusible elements having along their lengths portions of different characteristics with graded or constant cross sections and formed in such manner that upon slight overload the portions of different cross sections attain substantially simultaneously the required melting temperature and burn away. Other objects and the details of the manner of carrying out the present invention will be understood from the following description taken in conjunction with the accompanying drawing in which Fig. 1 illustrates diagrammatically a cross section of an exemplary form of fusible conductor constructed in accordance with the present inven-

tion; Fig. 2 shows in perspective a portion of a fusible conductor, having a cross section similar to that shown in Fig. 1, as one practical form in which the invention may be carried out; Figs. 3 and 4 illustrate in perspective two arrangements for carrying out the invention with ribbon type conductors, and Figs. 5 and 6 illustrate in perspective two other structural embodiments for carrying out the invention.

Although, as will be evident to one skilled in the art, the present invention may be practiced to advantage with different types and forms of electric fuses, the invention lends itself most advantageously to practice with the enclosed type of fuse such as disclosed in my previously referred to application wherein the fusible conductor is shown as being enclosed in a tubular casing of suitable insulating material and surrounded by or embedded in a pulverulent or sandy arc quenching material. The objectives of the present invention can be achieved, for example, by employing a fusible conductor the cross section of which is alternately increased or decreased, either continuously or in steps, in short succession. In Fig. 1 of the drawing is illustrated diagrammatically an exemplary embodiment of the invention wherein an extended fusible conductor 1, formed with a plurality of portions *a* of small cross section alternating in short succession with portions *b* of relatively larger cross section, is embedded in a filler 8 of pulverulent or sandy arc quenching material and enclosed in a casing 9 of insulation material. With a fusible conductor having such varying cross section, fusing takes place, upon occurrence of a short circuit or large or medium overloads, in so short a time that there is no appreciable radiation or conducting away of heat from the conductor so that the fusing of the conductor is effected progressively or in stages beginning with the parts *a* of smaller cross section and extending to the parts *b* of larger cross section in a manner similar to that described in connection with the fuse disclosed in my previously identified application. However, in case of slight overload as previously pointed out, it is desirable that both the sections *a* of small cross section and the sections *b* of large cross section attain substantially simultaneously the required melting temperature so that the different portions of the conductor will dissipate substantially simultaneously. To effect this desired purpose, the fusible conductor should be constructed so that in the case of slight overloads the larger cross section portions *b* are heated from the narrower cross section portions *a* whereby both the sections *a* and the sections *b* attain the same temperature practically at the same time and the fusible conductor fuses at all points almost at the same time. This may be effected by giving the fusible conductor a smaller

heat radiating surface at points of larger cross sections or by arranging the fusible conductor in such manner that the heat delivery or radiation at points of larger cross section are reduced.

- 5 Fig. 2 illustrates one practical construction of fusible conductor for securing the desired operation thereof as outlined in the previous paragraph. In this case the portions 10 of the fusible conductor, corresponding to the portions b of 10 Fig. 1, are made round so that they have a small heat radiating surface relative to the mass of the conductor at these points, while the portions 11, corresponding to the portions a of Fig. 1, are made of smaller total cross section than the portions 10 and are flattened out so that they have 15 a large heat radiating surface relative to the mass of the conductor at these points.

- In Fig. 3 is illustrated a ribbon or band type fusible conductor arranged in accordance with 20 the present invention in folded or zig-zag form so that the portions 12 of larger cross section will upon slight overload radiate or deliver less heat than the portions 13 of smaller cross section. In accomplishing this the folding of the conductor 25 is effected at points midway of the larger cross section portions and the adjacent surfaces of the conductor at the points of folding are brought relatively close together so that they tend mutually to heat each other while the portions of smaller 30 cross sections are spread apart so that they have maximum heat dissipation. A similar result may be obtained with a conductor wound spirally upon a core of ceramic material such as that indicated at 14 in Fig. 4. In this case the conductor is 35 wound upon the core in such manner that the distance apart of the turns of the larger cross section portions of the conductor is maintained smaller than the distance apart of the turns of the smaller cross section portions of the conductor. Thus the larger cross section portions tend to heat each other and retard the heat dissipation therefrom while the smaller cross section portions have maximum heat dissipation.

- A further method of carrying out the present invention is illustrated in Fig. 5 wherein is shown a portion of a fusible conductor having alternate sections of different material and different cross sections. The sections connected in series, in this case, are constructed to have different melting characteristics which can be determined by appropriate selection of the material employed in accordance with their melting points and electric conductivities and by appropriate formation of the conductor so that the relations of cross 55 section to heat radiating surface give the proper specific coefficient of heat dissipation. Thus the smaller cross section portions 17 of the conductor may be constructed of silver or similar metal having a relatively high melting temperature while the portions 18 of larger cross section may 60 be constructed of tin or like metal having relatively low melting temperature. The same result may be accomplished as illustrated in Fig. 6 by covering the larger cross section portions of the conductor with bodies 19 of fusing solder or other 65 substance for retarding the heat dissipation at these points with a consequent effective lowering of the melting point. Thus upon slight overload the portions 19 attain the required melting temperature substantially at the same time that the portions 20, of smaller cross section, attain their required melting temperature.

- From the foregoing description, it will be evident to one skilled in the art that the present invention is not limited to the details of the illus-

trated embodiments and that with a proper understanding of the principles underlying the invention as set forth hereinbefore the invention can be carried out with different forms and arrangements of conductors and with different materials. 5

What I claim as new and desire to secure by Letters Patent in the United States is:

1. In an enclosed fuse of the current limiting type, an elongated fusible conductor formed and arranged to attain required fusing temperature and dissipate initially throughout only a predetermined small portion of its length upon being subjected to a very large excess current and to attain required fusing temperature and dissipate 15 thereafter progressively throughout a considerably greater portion of the remainder of the length of the conductor upon continuation of such large excess current, said conductor being formed and arranged also to have thermal characteristics 20 effective upon subsection of the conductor to a relatively long continued small excess current to cause said second mentioned portion of the conductor to attain required fusing temperature and dissipate substantially simultaneously with said 25 first mentioned portion of the conductor.

2. In an enclosed fuse, a filler of arc quenching material, an elongated fusible conductor embedded in said filler, means operative upon subsection of said conductor to a very large excess 30 current for causing initially only a small portion of the length of the conductor to attain fusing temperature and dissipate and for causing thereafter a considerably greater portion of the remaining length of the conductor progressively to attain fusing temperature and dissipate, and 35 means operative upon subsection of the conductor to a relatively long continued small excess current for controlling the heat dissipation of one of said portions of the conductor relative to the heat dissipation from the other of said portions of the conductor in a manner to cause said second portion of the conductor to attain fusing temperature and dissipate substantially simultaneously with said first portion of the conductor. 4

3. In an enclosed fuse, a body of arc quenching material and a conductor having an elongated fusible section embedded in said material and designed to fuse throughout substantially the whole of its length upon subsection thereof to an excess current of predetermined magnitude, 50 which said fusible section of said conductor has small cross section portions alternating along its length with substantially larger cross section portions so that upon subsection of the conductor to a large excess current the said small cross section portions attain fusing temperature and dissipate prior to attainment of fusing temperature and dissipation by said larger cross section portions, said small cross section portions and said 60 larger cross section portions being formed and arranged to have relative to each other such different thermal characteristics that both the small cross section portions and the larger cross section portions attain fusing temperature and dissipate substantially simultaneously upon subsection of the conductor to a relatively long continued small overload current. 65

4. In an enclosed fuse, a body of arc quenching material and a conductor having an elongated fusible section embedded in said material and designed to fuse throughout substantially the whole of its length upon subsection thereof to an excess current of predetermined magnitude, said section of the conductor having a plurality of

portions of small cross section and a plurality of portions of relatively larger cross section alternating in short succession with said portions of small cross sections, said portions of larger cross section being formed and arranged to have such thermal characteristics relatively to the thermal characteristics of said portions of small cross section that upon relatively long continued small current overload the larger cross section portions attain their fusing temperatures and dissipate substantially simultaneously with said small cross section portions.

5. In an enclosed fuse, a body of arc quenching material and a conductor having an elongated fusible section embedded in said material and designed to fuse throughout substantially the whole of its length upon subjection thereof to an excess current of predetermined magnitude, said section of the conductor being formed with its cross section increasing substantially continuously in both directions from portions of reduced cross section to portions of relatively larger cross section, the reduced cross section portions and the larger cross section portions being formed and arranged to have relatively to each other such thermal characteristics that upon passage of a relatively long continued small overload current therethrough both said portions of reduced cross section and said portions of larger cross section attain their fusing temperatures and dissipate substantially at the same time.

6. In an enclosed fuse, a body of arc quenching material and an elongated fusible conductor embedded in said material and formed with a cross section increasing substantially continuously and relatively gradually from a portion of small cross section to a portion of large cross section, said small cross section portion and said large cross section portion being formed and arranged to have, upon subjection of the conductor to a relatively long continued small current overload, such different rates of heat dissipation that the large cross section portion attains fusing temperature substantially simultaneously with the attainment of fusing temperature by the small cross section portion of the conductor.

7. In an enclosed fuse, a body of arc quenching material and an elongated fusible conductor embedded in said material and formed with a cross section increasing substantially continuously and relatively gradually from a portion of small cross section to a portion of large cross section, said large cross section portion being constructed to have a ratio of heat dissipating surface to mass which is sufficiently smaller than the ratio of heat dissipating surface to mass of such small cross section portion that upon subjection of the conductor to a relatively long continued small current overload the large cross section portion attains its required fusing temperature substantially simultaneously with said small cross section portion.

8. In an enclosed fuse having a filler of arc quenching material, an elongated fusible conductor embedded in said filler and formed with a large cross section at spaced points along its length and with cross sections substantially continuously decreasing from said spaced points to a point intermediate said spaced points at which intermediate point the conductor is of substan-

tially reduced cross section, said conductor being irregularly disposed in said filler with portions of the length thereof in laterally spaced relation with respect to other portions of the length of the conductor and in such manner that the spacing between the portions of the conductor having the larger cross sections and the portions of the conductor lying laterally adjacent to the portions of larger cross section is less than the spacing between the portions of the conductor having the smaller cross sections and the portions of the conductor lying laterally adjacent to the portions of smaller cross section.

9. In an enclosed fuse having a filler of arc quenching material, a fusible conductor embedded in said filler and having along its length alternate portions of small and relatively larger cross section, said conductor being arranged in zig-zag folds in such manner that the distance apart of the folds at points of larger cross section of the conductor is smaller than at points of smaller cross section of the conductor.

10. In an enclosed fuse having a filler of arc quenching material, a fusible conductor embedded in said filler and having along its length alternate portions of small and relatively larger cross section, said conductor being wound in substantially spiral form with the distance apart of the turns of the conductor at points of larger cross section thereof maintained smaller than the distance apart of the turns at points of smaller cross section.

11. In an enclosed fuse having a filler of arc quenching material, a fusible conductor embedded in said filler and having along its length alternate portions of small and relatively larger cross section, and a heat dissipation retarding covering applied to the larger cross section portions of the conductor operative upon subjection of the conductor to a relatively long continued small current overload for effecting sufficient retardation of the heat dissipation from said larger cross section portions to cause the larger cross section portions to attain fusing temperature substantially simultaneously with the small cross section portions of the conductor.

12. In an enclosed fuse of the type including a body of arc quenching material and an elongated fusible conductor embedded in said material and designed to fuse throughout a relatively large part of its length upon subjection thereof to an excess current of predetermined magnitude, said part of the conductor having along its length a portion of reduced cross section arranged to attain fusing temperature and dissipate prior to attainment of fusing temperature and dissipation of the remaining portions of larger cross section of said part of the conductor upon subjection of the conductor to a large excess current, a construction and arrangement of said conductor such that the relation between the thermal characteristics of said larger cross section portions and of said reduced cross section portion is effective upon subjection of the conductor to a relatively long continued small current overload to cause substantially simultaneous attainment of fusing temperature and dissipation by both said reduced cross section portion and said larger cross section portions.

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