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V. N. STEWART

2,866,037

ELECTRIC CURRENT LIMITING FUSE

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Fig. 1.

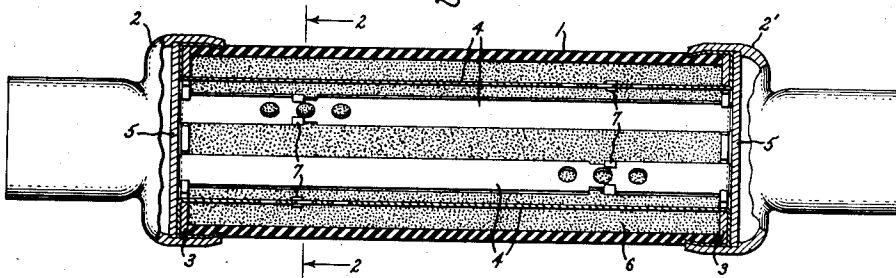


Fig. 2.

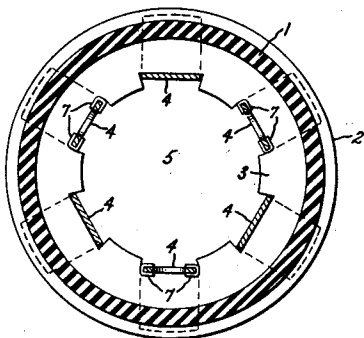


Fig. 5.

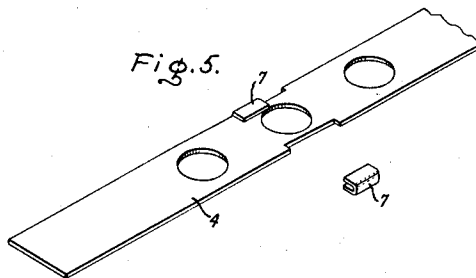


Fig. 4.

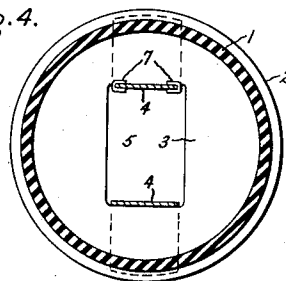


Fig. 3.

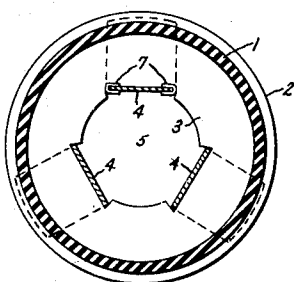


Fig. 6.

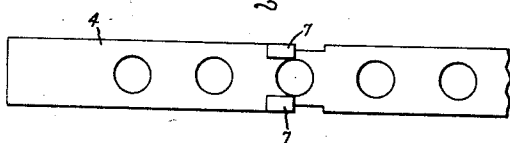
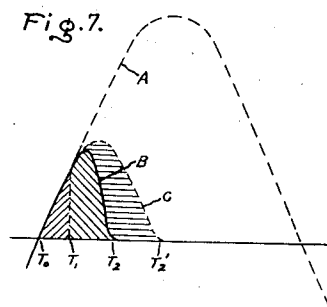


Fig. 7.



Inventor:
Vincent N. Stewart,
by *Walter H. Kaulner*
His Attorney.

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2,866,037

ELECTRIC CURRENT LIMITING FUSE

Vincent N. Stewart, Springfield, Pa., assignor to General Electric Company, a corporation of New York

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15 Claims. (Cl. 200—120)

My invention relates to electric current limiting fuses, and more particularly to high current interrupting capacity fuses having a plurality of individual fuse links of the constrictive section type disposed in substantially parallel spaced-apart relation in a single fuse casing. The invention is especially applicable to multiple-link low voltage current-limiting fuses of the sand-filled constricted-section type.

Current limiting fuses have been used heretofore in which several fuse links are mounted side by side in a single casing. When these links are of the constricted section type having one or more portions of reduced cross-sectional area and the constricted sections are positioned side by side, a large amount of arc energy is dissipated in a small axial length of the fuse. This localized energy dissipation causes undesirable heating at one point. When the fuse is of the sand-filled type, this undesirable heating takes place in a relatively small volume of the sand. It has been found that by this action the insulating quality of the sand is partially destroyed, and the sand is converted to a semi-conductor during the interrupting action. This effect is, of course, very detrimental to the interrupting capacity of the fuse.

Accordingly, therefore, it is a principal object of my invention to improve the interrupting characteristics of multiple link electric current fuses.

It is a more particular object of my invention to reduce the arc energy and reduce the ratio of arc energy to fusing energy in current limiting fuses of the multiple link constricted-section type, particularly in such fuses of the sand-filled type.

It is another object of my invention to improve the interrupting capacity of sand-filled current limiting fuses of the multiple link constricted-section type.

It is a particular object of my invention to minimize the arcing energy and to improve the interrupting characteristics of low voltage current limiting fuses of the sand-filled multiple link type in which each link is provided with a constricted portion of minimum cross-sectional area.

In carrying out my invention in one form I provide, within a single cylindrical insulating fuse casing, a plurality of individual fuse strips, or links, disposed in substantially parallel spaced-apart relation and electrically connected in parallel between terminals at opposite ends of the casing. Each fuse link is provided with a plurality of perforations thereby to form a plurality of serially related portions of reduced cross-sectional area, and the links are positioned in the casing so that reduced portions of adjacent links are in longitudinally offset relation. If a portion of minimum cross-section or neck portion is provided in each link, these neck portions are also longitudinally offset with respect to each other, as by forming the neck near one end of each link and oppositely disposing the links in the casing.

In a preferred embodiment of my invention, each fuse link is perforated in only a single eccentric region, and provided also with an eccentric constricted neck portion

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if desired. Additionally, I preferably provide at one of the reduced portions, for example at the neck portion, a quantity of alloy-forming material mounted on the link to define a section subject to initial fusing upon the occurrence of relatively low, protracted overload currents, as distinguished from short-circuit currents. Adjacent individual fuse links within the casing are relatively oppositely disposed between the terminals, so that the eccentric regions of constricted cross-section for adjacent links are longitudinally offset with respect to each other. For fuses provided with a plurality of pairs of links this results in locating the constricted regions of alternate links adjacent one fuse terminal and the constricted regions of the intermediate links adjacent the opposite fuse terminal. For the special case of an odd number of links arranged in a ring, there will always be one single pair of adjacent links similarly disposed, but even in this case a third link adjacent either link of this pair is oppositely disposed. Thus in my appended claims where it is stated that adjacent links are relatively oppositely disposed, I intend to include the special case of an odd number of links arranged in a ring.

My invention will be more fully understood and its various objects and advantages further appreciated by referring now to the following detailed specification taken in conjunction with the accompanying drawing and its scope will be pointed out in the appended claims. In the drawing, Fig. 1 is an axial cross-sectional view of a multiple link fuse embodying my invention; Fig. 2 is a transverse cross-sectional view of the fuse shown at Fig. 1 taken along the line 2—2 of Fig. 1 looking at the direction of the arrows; Figs. 3 and 4 are similar transverse cross-sectional views of other fuses embodying my invention in modified form; Figs. 5 and 6 are exploded perspective and plan views, respectively, of two types of fuse links usable in conjunction with my invention; and Fig. 7 is a graphical representation of the improved current limiting action resulting from my improved fuse construction.

Referring now to the drawing, and particularly to Figs. 1, 2 and 5, I have shown a multiple link fuse comprising an elongated cylindrical casing 1 of insulating material provided at opposite ends with electrically conductive terminals 2 and 2'. The terminals shown have knife blade connecting or contact portions and cup-shaped closure portions fitting over the ends of the tubular fuse casing 1. Each end of the tubular insulating casing 1 is provided with an overlying metallic annulus or washer 3 having six notches symmetrically disposed around its inner peripheral edge (Fig. 2). Between each aligned pair of notches in the opposite end washers 3 there is tightly strung a fuse link 4. The opposite ends of each fuse link are turned radially outward over the outer surfaces of the end washers 3 and over the outer surface of the insulating casing 1, where they are mechanically fastened by crimping under the cap portions of the terminals 2—2'. Within the terminal end caps and overlying the end washers 3, I provide also electrically conductive metallic closure disks 5 for retaining within the casing a body of pulverulent arc extinguishing filler material, such as quartz sand 6. The body of filler material, such as sand, completely fills the cylindrical casing 1 between the closure plates 5, and the fuse strips 4 are thus directly embedded in the filler material.

At Fig. 5 I have shown a fragmentary exploded perspective view of one of the fuse strips 4 shown at Figs. 1 and 2. As will be observed from Figs. 1 and 5, each fuse strip 4 is provided in a single eccentric region adjacent one end with three longitudinally aligned circular perforations, thereby to provide three serially related portions of reduced cross-sectional area. Additionally the strip 4 is perforated or notched at its edges adjacent

the central aperture, thereby to provide one constricted neck portion of minimum cross-sectional area. Preferably the fuse link or strip is formed of silver and has mounted thereon one or more alloy-forming members formed of tin. Such alloy-forming members are shown at Fig. 5 as a pair of tin clips 7 attached to the strip 4 by crimping on to the strip adjacent the constricted neck portion formed by the edge notches. As is well understood by those skilled in the art, the tin clips 7, preferably attached to the silver strip 4 with the aid of a fluxing agent (interposed between the clips and the silver strip 4), ensure fusing of the link in the region of the clip upon protracted relatively low overload currents. This effect arises from the fact that each tin clip 7 when heated by protracted overload currents forms with the silver a eutectic alloy having a melting point lower than the melting point of either the silver or the tin.

At Fig. 6 I have shown a fuse link similar to that shown in Fig. 5 except that the strip is provided, in a single eccentric region, with five longitudinally aligned central apertures or holes rather than three, corresponding parts of Figs. 5 and 6 being assigned the same reference numerals. It will of course be appreciated by those skilled in the art that the number of reduced cross-sectional portions provided in each strip is not germane to my invention.

Referring now again to Fig. 1 it will be observed that the individual fuse links within the fuse casing 1 are oppositely disposed between the terminals 2 and 2', so that the eccentric regions of reduced cross-sectional area of any two adjacent strips are longitudinally offset with respect to each other. In the six-link fuse shown at Figs. 1 and 2 this results in one group of three alternate fuse strips being positioned with their eccentric regions of reduced cross-sectional area adjacent to one terminal and the intermediate group of three strips being positioned with their eccentric regions of reduced section adjacent the opposite terminal. By reason of the peripheral location of the mounting notches in the end washers 3 the fuse strips are disposed in substantially parallel spaced-apart relation within the casing 1.

At Figs. 3 and 4 I have shown additional embodiments of my invention similar in all respects to that shown at Figs. 1 and 2 except that in the embodiment of Fig. 3, three fuse links are provided, with one disposed oppositely with respect to the other two, and at Fig. 4 only two fuse links are provided in opposite disposition.

When fuses embodying my invention are utilized in circuits having a sufficiently high short circuit current capacity, they operate with a current limiting action in that the maximum current permitted to flow prior to circuit interruption by fuse action is very appreciably less than the maximum short circuit current which such circuit would be capable of supplying in the absence of the fuse. Moreover the alternate or offset disposition of the constricted fuse link sections, by distributing the energy dissipated by arcing throughout a larger volume of sand so improves the current interrupting action that the arcing energy is markedly reduced with respect to fuses of similar structure having the constricted sections of all fuse links juxtaposed in side by side relation.

The foregoing current limiting and energy conserving action is illustrated in Fig. 7, wherein the broken line sinusoidal curve A represents a half cycle of the short circuit current which would flow in the circuit in the absence of any circuit interrupting means. The solid curve B illustrates a half cycle of the limited current which actually does flow in the same circuit prior to interruption by a suitable fuse embodying my invention; and the broken line curve C illustrates the declining current portion of a similar half cycle of limited current permitted to flow by a similar fuse in which the fuse links are not oppositely oriented. It will thus be observed from Fig. 7 that by merely alternately oppositely orient-

ing the individual fuse links in a multiple link fuse of the structure shown the short circuit current in any predetermined circuit is interrupted in a considerably shorter time and the energy dissipated by arcing is markedly reduced. In the diagram of Fig. 7, it is assumed that the short circuit occurs at time T_0 . As illustrated, fusing occurs at a time T_1 , so that the energy dissipated in fusion of the links is represented by the quantity $\int i^2 dt$ between the times T_0 and T_1 where i is the instantaneous current. Between the times T_1 and T_2 arc current is flowing in the fuse, so that the quantity $\int i^2 dt$ between the times T_1 and T_2 is representative of the energy dissipated in the fuse in arcing. It has been found experimentally that the ratio of arcing energy to fusing energy in a typical fuse embodying my invention is of the order of 5 to 1. On the other hand, as indicated by the diagram, had the fuse links been similarly, rather than oppositely oriented within the casing, the current would not have been interrupted until the time T_2 , and the ratio of arcing energy to fusing energy in such case was found to be of the order of 20 to 1. This indicates a marked reduction of arcing energy in the ratio of 4 to 1.

It will now be evident to those skilled in the art that it is not necessary to my invention that the perforations of each link be restricted to a single eccentric region, so long as the portions of reduced cross-section of each link are longitudinally offset in the casing with respect to the like reduced portions of adjacent links. Any constricted neck portions of the links, however, should be eccentrically located, and adjacent links oppositely disposed to offset such neck portions.

Thus, while I have shown and described only a single embodiment of my invention by way of illustration, many modifications will occur to those skilled in the art, and I therefore wish to have it understood that I intend in the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

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

1. In an electric current limiting fuse, a single undivided enclosing casing provided with a pair of electrically conductive terminals in spaced apart relation, a plurality of elongated fuse links mounted in said casing between said terminals in substantially parallel spaced-apart relation, said fuse links having oppositely disposed faces in substantially flatwise parallel relation, each said fuse link having a plurality of serially related portions of reduced cross-sectional area in a single eccentric region and adjacent links being oppositely disposed in said casing thereby to position the eccentric regions of adjacent links in longitudinally offset relation with the reduced region of each link lying in parallel spaced juxtaposition to an unreduced region of an adjacent link, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

2. In an electric current limiting fuse, a single undivided enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of elongated fuse links mounted in said casing between said terminals in substantially parallel spaced-apart relation, said fuse links having oppositely disposed faces in substantially flatwise parallel relation, each said fuse link having a plurality of serially related portions of reduced cross-sectional area in a single eccentric end zone thereof and adjacent links being oppositely disposed in said casing thereby to position said end zones in longitudinally offset relation with the reduced region of each link lying in parallel spaced juxtaposition to an unreduced portion of an adjacent link.

3. In an electric current limiting fuse, a single undivided enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of pairs of elongated fuse links mounted in a ring in said casing between said terminals and in substantially parallel spaced-apart relation, said fuse links having op-

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positely disposed faces in substantially flatwise parallel relation, each said fuse link having a plurality of serially related portions of reduced cross-sectional area in a single eccentric region and adjacent links being oppositely disposed in said casing thereby to position the eccentric regions of adjacent links in longitudinally offset relation with the reduced region of each link lying in parallel spaced juxtaposition to an unreduced region of an adjacent link, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

4. In an electric current limiting fuse, an enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of elongated fuse links mounted in said casing in substantially parallel spaced-apart relation, each said fuse link having a plurality of serially related portions of reduced cross-sectional area in a single eccentric region and having an eccentrically positioned neck portion of minimum cross-section, adjacent links in said casing being oppositely disposed thereby to position the eccentric regions and the neck portions of adjacent links in longitudinally offset relation, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

5. In an electric current limiting fuse, an enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of elongated fuse links mounted in said casing in substantially parallel spaced-apart relation, each said fuse link having a plurality of serially related portions of reduced cross-sectional area located in a single eccentric region and being provided in said region with a reduced neck portion of minimum cross-sectional area, adjacent links in said casing being oppositely disposed thereby to position the eccentric regions of adjacent links in longitudinally offset relation, and a body of pulverulent arc extinguishing material filling said casing directly and embedding said links.

6. In an electric current limiting fuse, an enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of elongated fuse links mounted in said casing in substantially parallel spaced-apart relation, each said fuse link having a plurality of serially related portions of reduced cross-sectional area and a reduced neck portion of minimum cross-sectional area in a single eccentric region, alloy-forming means associated with each said fuse link in its said eccentric region thereby to determine an initial fusing point of the link upon protracted low overload currents, adjacent links being oppositely disposed in said casing thereby to position the eccentric regions of adjacent links in longitudinally offset relation, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

7. In an electric current limiting fuse, an enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of elongated fuse links mounted in said casing in substantially parallel spaced-apart relation, each said fuse link having a plurality of serially related portions of reduced cross-sectional area and a reduced neck portion of minimum cross-sectional area in a single eccentric region, alloy-forming means associated with each said fuse link to determine a point of initial fusion upon protracted low overload currents, adjacent fuse links in said casing being oppositely disposed thereby to position eccentric regions of adjacent links in longitudinally offset relation, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

8. In an electric current limiting fuse, an enclosing casing of insulated material provided with a plurality of electrically conductive terminals in spaced-apart relation, a plurality of pairs of elongated fuse links mounted in said casing between said terminals in substantially parallel spaced-apart relation, each said fuse link having a plurality of serially related portions of reduced cross-sectional

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area and a reduced neck portion of minimum cross-sectional area in a single zone adjacent one end thereof, alloy-forming means associated with one reduced portion of each said link thereby to determine a point of initial fusion upon protracted low overload currents, adjacent links in said casing being oppositely disposed thereby to position the eccentric regions of alternate links adjacent one said terminal and the eccentric regions of intermediate links adjacent the other terminal, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

9. In an electric current limiting fuse, a single undivided enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of individual elongated fuse links mounted in said casing between said terminals in substantially parallel spaced-apart relation, each said fuse link having a plurality of serially-related and spaced-apart portions of reduced cross-sectional area and each link being disposed within said casing with each of its respective reduced portions in longitudinally offset relation with any reduced portion of an adjacent link, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

10. In an electric current limiting fuse, a single undivided enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of pairs of individual elongated fuse links mounted in said casing between said terminals in substantially parallel spaced-apart relation, each said fuse link having a plurality of serially-related and spaced apart portions of reduced cross-sectional area and each link being disposed within said casing with each of its reduced portions longitudinally offset with respect to the corresponding reduced portions of each adjacent link, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

11. In an electric current limiting fuse, an enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of elongated fuse links each provided with a plurality of serially related and spaced-apart portions of reduced cross-sectional area mounted in said casing between said terminals in substantially parallel spaced-apart relation, each said link having a reduced neck portion of minimum cross-sectional area adjacent one end thereof and adjacent links being oppositely disposed in said casing with their adjacent reduced portions and neck portions in longitudinally offset relation, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

12. In an electric current limiting fuse, an enclosing casing provided with a pair of electrically conductive terminals in spaced-apart relation, a plurality of elongated fuse links each provided with a plurality of serially-related and spaced-apart portions of reduced cross-sectional area mounted in said casing between said terminals in substantially parallel spaced-apart relation, each said fuse link having an eccentrically positioned neck portion of reduced minimum cross-sectional area and adjacent links in said casing being oppositely disposed in offset relation to position the neck portions and reduced portions of adjacent links in longitudinally offset relation, alloy-forming means associated with one reduced portion of each said link thereby to render said one reduced portion most readily fusible upon protracted low overload currents, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

13. In an electric current limiting fuse, an enclosing casing provided with a pair of electrically conducting terminals in spaced-apart relation, a plurality of elongated fuse links each having a plurality of serially-related and spaced-apart portions of reduced cross-sectional area mounted in said casing between said ter-

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minal in substantially parallel spaced-apart relation, each said link having an eccentrically positioned reduced neck portion of minimum cross-section and adjacent links being oppositely disposed in said casing in offset relation to position the neck portions and reduced portions of adjacent links in longitudinally offset relation, alloy-forming means associated with only one eccentrically positioned reduced portion of each said link, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said link.

14. In an electric current limiting fuse, a single undivided enclosing casing provided with a pair of electrically conductive terminals in spaced apart relation, a plurality of fuse links mounted in said casing between said terminals in substantially parallel spaced-apart relation, each said fuse link having at least one portion of reduced cross-sectional area and the reduced portions of each link being confined to a single region of a length no greater than half the length of the link between said terminals, means mounting adjacent links eccentrically and oppositely in said casing with their respective reduced portions in longitudinally offset relation, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

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15. In an electric current limiting fuse, a single undivided enclosing casing provided with a pair of electrically conductive terminals in spaced apart relation, a plurality of elongated fuse links mounted in said casing between said terminals in substantially parallel spaced-apart relation, each said fuse link having a plurality of serially-related portions of reduced cross-sectional area in a single region of a length no greater than half the length of the link between said terminals and adjacent links being oppositely eccentrically disposed in said casing to position said regions of adjacent links in longitudinally offset relation, and a body of pulverulent arc extinguishing material filling said casing and directly embedding said links.

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