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ELECTRIC FUSES

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The present invention relates to a current-limiting powder-filled electric fuse.

Such fuses are designed to operate very rapidly under short circuit conditions due to the interaction of the powder filling with the metal vapour produced from the fusible element. When such fuses are also to be used for overload protection, for example for protecting cables against overheating, for protecting lighting installations and for protection against high resistance earth faults, it is also desirable on the other hand that the "fusing factor" shall be as small as possible. The fusing factor is defined as the ratio of the minimum fusing current to the continuous current-carrying capacity of the fuse. If it is desired that the fusing factor, as above defined, of such fuses, shall be substantially less than 2 and, in particular, less than 1.5, considerable difficulty has heretofore been met in satisfactorily meeting this requirement, and the object of the present invention is to provide a construction of fuse permitting comparatively low values of the fusing factor, down to about 1.25 or below, to be reliably obtained.

In accordance with the present invention a current limiting powder-filled cartridge fuse includes a plurality of load-carrying fusible elements connected in parallel one with the other, one or more of which elements have different fusing characteristics from one or more other of said elements, but all of said elements have substantially similar current-carrying characteristics.

The said different fusing characteristics of one or more of the elements are such that said elements, or at least a certain part or parts thereof, melt at a lower current or more rapidly under moderate overloads; all the elements however are heated to approximately the same extent and in general they all carry approximately the same proportion of the total current and moreover they all fuse simultaneously under short circuit conditions.

By this construction a fuse can be produced having a comparatively low fusing factor (as above defined), substantially below 1.5—down to about 1.25 or even less. In operation under overload conditions the overload current is initially distributed uniformly between the several elements, but that element or those elements which is/are adapted to fuse at a lower current or more rapidly, is/are caused to melt and break the current path through it or them, with the result that the current previously carried by it or them is transferred to the other element or elements and the latter now interrupt the circuit current by fusing in the normal manner by virtue of the additional current carried by it or them.

The invention may be carried into effect in various ways and in each case an outer case or cartridge is provided enclosing a powder filling having arc quenching properties. The powder encloses a plurality of fusible elements each preferably having a central section of reduced width or cross sectional area. According to an important feature of the invention said central section preferably also has one or more apertures in the reduced width or area to provide an improved action under short circuit

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conditions—in particular to ensure that, although the fuse ensures clearance during the first half cycle of fault current, the current shall not be interrupted in a manner such that dangerously high voltages are produced in the circuits to which the fuse is connected. In one form of the invention all the elements are formed of the same material and of the same section (preferably silver strip) so that they fuse simultaneously under short circuit conditions, but one group of said elements (consisting of one or more but not all of the elements) is modified so that at least a part of said element or elements fuses or melts more easily or more rapidly for moderate overloads.

All the fusible elements, being of similar section, are preferably formed of silver strip owing to its low specific resistance and to the favourable action obtained between the silver vapour and the powder filling upon fusing.

The modification of one or more of the strips where they are all of similar metal is obtained by the fact that said elements are severed or partially severed into two sections, and the division or partial division is surrounded and united by means of a piece or bead of low-melting point material, for example solder. This piece or bead of low melting point material is so arranged that it melts under overload conditions, causing interruption of the flow of current through the element. Moreover this section of the strip is protected by the surrounding low melting point material from thermal conduction towards the powder filling with the result that under overload conditions the section of the fusible strip enclosed by said low melting point material becomes heated to a greater extent and thus facilitates or initiates melting of the low melting point material and/or of the fusible element concerned at a relatively low value of overload. This action is facilitated by the severance or partial severance of the fusible element at the point enclosed by the lower melting point material but it should be understood that such severance or partial severance need not always be provided, it being sufficient under certain conditions merely to provide a small mass or bead of low melting point material around the fusible strip. In those forms of the invention wherein part of the fusible element is surrounded by a mass or bead of low melting point material, this material is located towards one end of the element to which it is applied thereby ensuring that the interaction between the fusible element and the powder filling shall not be lost when the fuse operates under short circuit conditions.

Preferred embodiments of the invention are illustrated by way of example on the accompanying drawings in which:

Fig. 1 is a general view of a powder filled cartridge fuse, part of the cartridge being cut away to show the internal arrangement of the fusible elements and of the powder filling.

Figs. 2 to 4 are enlarged sections through the fusible strips showing various embodiments of the invention.

Fig. 5 is a view of a fusible element similar to Fig. 2 but incorporating spring means to assist in obtaining a clear break and also arranged for the operation of a visual indicator.

Referring first to Fig. 1 of the drawing it will be seen that the fuse consists of an outer cartridge 7 preferably of glazed ceramic material to which end caps 8 are sealed. Metal connector blocks 9 are connected to the end caps, which are moreover coupled with terminal means such as connector plates 10 by which the fuse is connected into the circuit. The metal connector blocks 9 serve as terminals for the attachment, by spot welding, of the fusible elements, three of which are shown by way of example at 11, 12 and 13. It is to be understood that any desired number of such fusible elements are provided according to the rating of the fuse and they may either run, as indi-

cated in the drawing directly between the blocks 9, or they may if desired be wound on a tubular or other ceramic core. In practice they would be spaced equidistantly around the central axis, but they are shown developed, i. e. side by side, for convenience. The fusible elements are enclosed by a powder filling 14, as is well known in the art, for the purpose of obtaining a high resistance break between the blocks 9 upon interruption of the circuit by the fuse by interaction between the volatilised metal of the elements 11, 12 and 13 with the powder filling.

These elements are preferably formed of silver strip and the centre parts thereof are of reduced width as indicated at 15. As is well known this type of fuse is capable of acting as a current limiting fuse ensuring, under short circuit conditions, interruption of the current in the course of the first half cycle of the fault current. An important feature of the invention is that holes 16 are provided near the ends of the centre parts. This construction ensures optimum operation under short circuit conditions, in particular by ensuring that fusing occurs initially at the centre of each element and then spreads progressively towards the ends, thus ensuring a quick interruption of the flow of fault current but not however in such manner as might engender the production of excessive voltages in the circuit.

As indicated above the present invention includes provision to ensure a low fusing factor and for this purpose one or more but not all of the fusible elements, for example the fusible element 12 in the example shown, which utilises three elements in all, is arranged to have different fusing characteristics under moderate overload conditions, from the other element or elements. For this purpose and as shown in Figs. 1 and 2 the strip forming the fusible element 12 is severed near one end as indicated at 17 and the severed parts are united by enclosing them with and uniting them by a section or bead 18 of different material, more especially a material having a lower melting point, such as solder. All the fusible elements carry, at normal current rating, the same proportion of the total current carried by the fuse at a low temperature rise and they become heated to about the same extent.

The action is as follows on the occurrence of a moderate overload, say of about 1.25 times the normal fuse rating or even less: All the elements are heated to about the same extent and under this overload the temperature is such that the bead 18 of the lower melting point material melts and the current flowing through the particular element (i. e. element 12) concerned, is interrupted. Consequently the proportion of the current previously carried by the said element is diverted to the other elements 11 and 13 and thus the additional current therein is sufficient to cause them to fuse in the normal manner, resulting in complete interruption of the circuit between the conductor blocks 9. Of course all three elements 11, 12 and 13 fuse instantaneously in the normal manner under short circuit conditions.

In certain circumstances it may not be necessary to provide complete severance of the strip 12 as shown in Fig. 2, and it may be sufficient, as shown in Fig. 3, to provide a single transverse depression or opposed depressions 19, which likewise are surrounded by a bead of low melting point material 18. Moreover as shown in Fig. 4 no severance or depression 19 need be provided in some circumstances, in which case the strip 12 is merely surrounded by a bead of low melting point material 18. In this case the bead 18 serves to reduce the transmission of heat from the fusible element 12 at the point enclosed by the bead resulting in a greater degree of heating in the strip at this point and permitting melting to occur preferentially in the part of the strip enclosed by the bead.

If desired means may be provided to ensure a greater separation of the two parts of the strip 12 adjacent the point enclosed by the bead 18 of low melting point material, whether this is arranged as shown in Figs. 1 and

2, or as shown in Fig. 3, or as shown in Fig. 4. For this purpose and as shown in Fig. 5 a compression spring 20 may be located between abutments 21 fitted to the strip 12 adjacent and at either side of the bead 18 with the result that when melting of the fusible element 12 occurs the spring 20 serves to push apart the fused ends of the strip ensuring a more definite break at these points.

The invention preferably also includes an indicator plunger 22 (Figs. 1 and 5) which is adapted to show the condition of the fuse. As shown in Fig. 1 the plunger 22 is normally located in a cavity 23 in one connector block 9 and is urged outwardly by a compression spring 24 disposed in said cavity. The plunger 22 is, however, held in its normal position by a length of wire 25, for example of nickel chrome alloy which is anchored to the opposite connector block 9 and which includes a tension spring portion 26. When fusing of the fusible elements occurs current is diverted into the wire 25 which therefore also fuses and releases the plunger 22 which moves outwardly under the action of the spring 24 to give a visual indication.

As shown in Fig. 5 a wire 27 of any suitable material is linked to the nearest lug 21 so that in the event of operation of the fuse the action of the compression spring 20 serves to release the tension on the wire 27, and allow the plunger 22 to move outwardly as explained in connection with Fig. 1.

In the embodiments described all the fusible elements have been of the same material and some but not all of them have included means such as a bead 18 of low melting point material, in conjunction with the severed portion 17 (Fig. 2) or with a recess or recesses 19 (Fig. 3) or disposed around the strip 12 without severance and without recesses (Fig. 4), but the invention is not limited to this construction, but only by the claims to the construction which causes the strip 12 to fuse before the strips 11 and 13 under overload conditions resulting in the action described, whereas under short circuit conditions all the elements fuse substantially together in the normal manner applicable in the case of powder filled fuses.

What we claim is:

1. A current limiting powder filled fuse comprising conductive connector blocks disposed at opposite ends of the fuse, conductive connectors respectively connected to said conductive blocks for connecting said fuse in a circuit, a plurality of identical highly conductive fusible elongated elements extending between and connected at the respective ends thereof separately to said conductive connector blocks, said elements being in the form of thin strips of the same length and of the same cross-section in corresponding portions of the length thereof to insure even sharing of the load current between said elements and simultaneous operation on short circuit faults, an outer casing, a filling of arc-quenching powder within said casing and surrounding all said strips in heat transferring relation thereto, all of said strips and said powder filling being selected to operate with current limiting action upon operation of said fuse, at least a selected one of said strips carrying a mass of low melting point metal in conductive contact with and surrounding a short portion of the length of said selected strip, said mass of metal being omitted from at least another of said strips to impart under overload current conditions to said selected strip a fusing characteristic different from said other strip to cause preferential fusing of said selected strip under such overload current conditions.

2. A current limiting powder filled fuse as defined in claim 1 in which the cross-section of said selected strip at said short portion of the length of said strip is reduced within said mass of low melting point metal carried by said strip.

3. A current limiting powder filled fuse as defined in claim 1 in which the material of said strips is silver.

4. A current limiting powder filled fuse as defined in

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claim 1 in which the metal of said mass carried by said selected strip is solder.

5. A current limiting powder filled fuse comprising conductive connector blocks disposed at opposite ends of the fuse, conductive connectors respectively connected to said conductive blocks for connecting said fuse in a circuit, a plurality of identical highly conductive fusible elongated elements extending between and connected at the respective ends thereof separately to said conductive connector blocks, said elements being in the form of thin strips of the same length and of the same cross-section in corresponding portions of the length thereof to insure even sharing of the load current between said elements and simultaneous operation on short circuit faults, an outer casing, a filling of arc-quenching powder within said casing and surrounding all said strips in heat transferring relation thereto, all of said strips and said powder filling being selected to operate with current limiting action upon operation of said fuse, at least a selected one of said strips carrying a mass of low melting point metal in conductive contact with and surrounding a short portion of the length of said selected strip, said selected strip being severed into two parts in said short portion thereof within said mass of low melting point metal, the ends of said parts being adjacent but spaced apart lengthwise of said selected strip, said mass of metal filling said space between said parts, said mass of metal being omitted from at least another of said strips to impart under overload current conditions to said selected strip a fusing characteristic different from said other strip to cause preferential fusing of said selected strip under such overload current conditions.

6. A current limiting powder filled fuse as defined in

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claim 5 in which each of said strips has a portion thereof other than said short portion which is of reduced cross-section, said portion of reduced cross-section being of the same length and of the same cross-section in the corresponding portions of the several strips.

7. A current limiting powder filled fuse as defined in claim 6 in which said portions of said strips of reduced cross-section are provided in the respective strips with holes passing through said reduced portions adjacent an end of the length of said reduced portion.

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