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F. L. CAMERON

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CURRENT LIMITING FUSE

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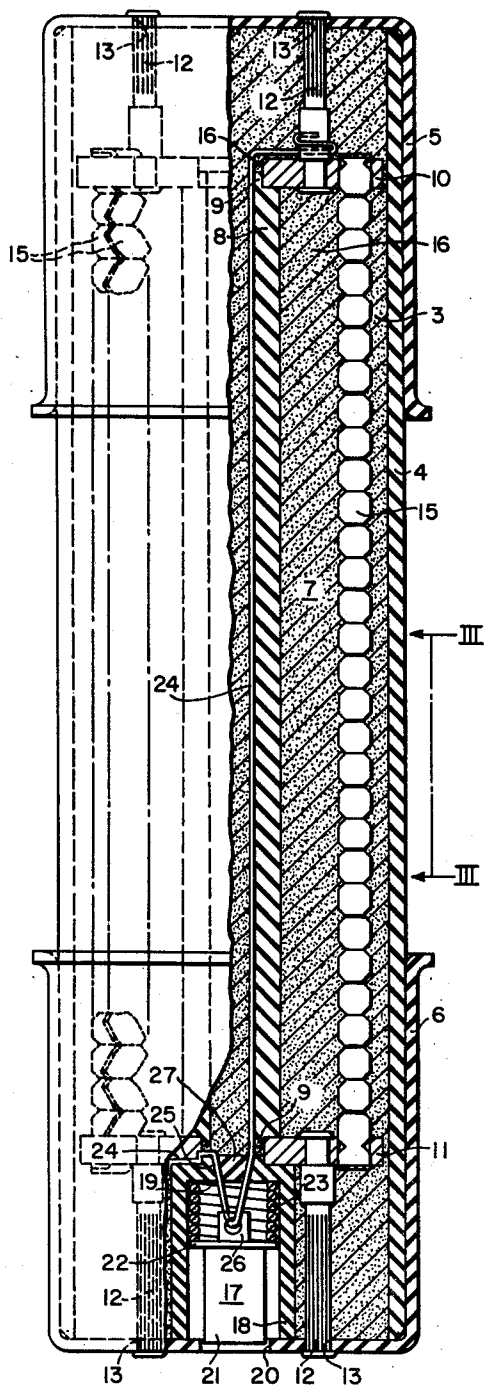


Fig. 1.

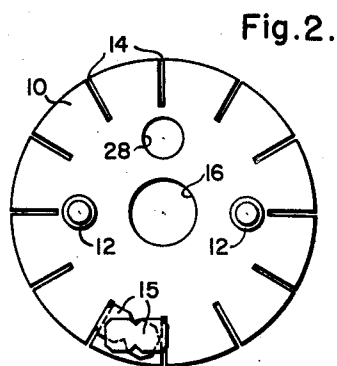
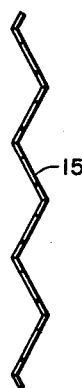


Fig. 2.

Fig. 3.



INVENTOR

Frank L. Cameron

BY
Ralph W. McIntire
ATTORNEY

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CURRENT LIMITING FUSE

Frank L. Cameron, North Huntingdon Township, Westmoreland County, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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This invention relates, in general, to electric circuit interrupting devices and, more specifically, to high voltage fuses of the type especially adapted to limit the current upon interruption of heavy overload and short circuits.

A limitation on the longevity of fuses, and particularly when the fuse is applied in motor starting operations, resides in the fatigue failure of fusible elements because of fracture resulting from repeated expansion and contraction of the fusible elements caused by changes in loading.

Accordingly, it is an object of this invention to provide a fuse having fatigue proof fusible elements therein.

It is another object of this invention to provide in an enclosed fuse more efficient heat dissipation from the fusible members to the outside walls of the fuse holder to thus increase the fuse rating.

In practicing this invention in one of its forms, there is provided a fuse designed basically of silver and sand construction, thus substantially eliminating all organic gas evolving materials from the fuse to facilitate hermetically sealing the fuse for use in explosive atmospheres. The exceptions lie in the melamine binder in the glass melamine outer casing of the fuse, and in the plastic operation indicator. The glass melamine construction material of the tube is preferable to other materials conventionally used in the construction of fuse tubes, such as glass epoxy, because of its superior heat and arc resistant properties which contribute to the novel positioning of the fuse elements radially near the inside wall of the tube to achieve the lowest possible resistance to heat flow between the heat source, the fusible elements, and the cooling surface, as represented by the outer wall of the tube. The glass melamine material permits a closer proximity between the fuse elements and the fuse tube than would be permitted by other materials without scorching and deterioration of the fuse tube. The fusible elements are further arranged with the thin edge of the ribbon or strap pointing radially outward to maintain each fulgurite formed about the individual strap during interruption and prevent merging of the individual arcs.

Each of the individual fuse elements is prebent or indexed periodically along its length to provide equal distribution of the flexing of the fuse element throughout the length of the fusible element to reduce flexing to a point within the endurance range of the metal, thus preventing the element from breaking, that is, rendering the fuse elements fatigue proof. Heretofore, fusible elements have been made non-linear for various reasons such as to minimize contact between the fuse element and the walls of the fuse holder when the fuse element expands, as for example in Patent No. 2,828,390. However, the prior art does not show prebending in a fashion to render the fuse elements fatigue proof.

The fuse elements are securely fastened to slotted, heavy copper discs near the ends of the fuse holder. The copper discs serve both to connect the fuse elements in parallel and as heat wells which readily absorb heat generated in the fuse elements during motor starting intervals, giving the fuse a higher, short time thermal capacity. The end caps or ferrules are pressed over the glass melamine tubing and cemented in place resulting in a fully sealed extremely strong assembly of fuse tube and ferrules.

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The invention will be more apparent upon consideration of the following description when taken in connection with the attached drawing, in which:

FIGURE 1 is a substantially central longitudinal section through one embodiment of a fuse constructed in accordance with this invention;

FIGURE 2 is a top plan view of an end terminal and fuse element spacer assembly used in the fuse of FIGURE 1; and,

FIGURE 3 is an enlarged view of a portion of a fuse element used in the fuse of FIGURE 1, taken in section substantially along the lines III—III of FIGURE 1.

Referring to the drawing, there is shown a fuse of the multi-link type and comprising a tubular fuse holder 4 constructed of glass melamine material. The tubular fuse holder 4 is provided with metal end caps 5 and 6 adapted to be secured over opposite ends of the tube 4. The end caps 5, 6 may be of any desired construction, but are preferably of one piece construction and silver plated over the entire surface. The end caps 5, 6 may be secured to the holder 4 by any suitable means, but are preferably pressed over the glass melamine tubing 4 and cemented in place to provide a strong fully sealed assembly.

The current limiting and arc extinguishing structure is embodied in a unit generally indicated at 7, said unit comprising a subassembly including a tubular rod 8 of an insulating material, such as ceramic. The opposite ends of the rod 8 are provided with reduced portions 9, 9 each adapted to be received within a centralized mating aperture in end terminal elements 10, 11. The end terminals may be constructed of any conducting material, but are preferably comprised of copper. The rod 8 may be fixed to the terminals 10, 11 in any suitable manner, as by an adhesive.

Each terminal disc 10, 11 extends substantially across the tubular holder 4 and is provided with a pair of spaced conductor studs 12, 12, preferably of 1/4 inch copper, extending perpendicularly to the disc for mating relationship with suitable apertures 13, 13 in the end caps 5 and 6. The studs may be connected to the end caps at the apertures 13, 13 in any suitable fashion but preferably the studs are electrically connected to the end caps or ferrules by means of a mechanical spin-press fit which is then soldered to forestall any possibility of corrosion at the mechanical joint.

The terminal discs 10, 11 are identical, and are provided at their outer periphery with twelve radially disposed equally spaced narrow slots 14. Each slot 14 in one terminal disc is aligned with a slot 14 in the opposite terminal disc, each pair of aligned slots being provided with a fusible element 15 extending therethrough. Only one fusible element is shown in the drawing for clarity of disclosure. The ends of the fusible element 15 are fitted in the aligned slots and are bent over at the ends and may be soldered to the copper end terminal if desired. It is to be understood that when fusible elements are placed in adjacent slots 14, their end portions may be bent over each other and soldered together in the manner indicated in dotted lines in FIGURE 2 to thus minimize the number of soldering operations required.

Each fusible element 15 is ribbon-like in form and preferably comprised of silver. The ribbon is segmented by V-notching on both edges periodically along its length to provide a series of restricted areas which fuse to provide a series of arcs, the summation of which provides a high arc voltage as is known in the art. For example, in a fuse constructed in accordance with the teachings of this invention, the silver ribbon elements were 1/4 inch wide by .005 inch thick and were provided with V-notches having an included angle of about 36° at 1/4 inch intervals along its length.

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Referring now to FIGURE 3, there is shown the zig-zag appearance of the fuse element 15 resulting from preindexing or prebending of the element periodically along its length, each successive bend being equal and opposite to the adjacent bends relative to a central axis along the fusible element.

Investigations with non-indexed ribbon type fusible elements have shown that expansion and contraction of the fusible element effected pronounced flexing at one or two points along the lines of the fuse, ultimately causing the fuse to fracture under fatigue failure.

Preindexing of the fusible element, as shown in FIGURE 3, effects uniform distribution of the flexing among the various indexed points with the result that variation in stress intensity at any one point is kept within the endurance range of the metal, and the element does not break. Preferably, the fusible elements should be bent as sharply as possible at the points of indexing without damaging the surface of the wire. It is apparent that the minimum number of indexed points is dependent upon the length of the fusible element and the amount of expansion and contraction anticipated for the particular material. As an example of fatigue proofing of a fusible element through prebending or preindexing as shown, a silver strap of the type hereinbefore described, having a length of ten inches, was indexed at about 1/4 inch intervals to an included angle of about 120° resulting in a fuse having fatigue proof elements.

The construction of the fuse as hereinbefore described wherein the terminals 10 and 11 may be attached to the support rod 8 and fuse elements 15 as a self-supporting subassembly permits the testing of the interrupting unit 7 alone before insertion in the tubular holder 4 and end caps 5 and 6 and the surrounding granulated insulating medium 16 such as silica sand. This is an important advantage in manufacturing as it readily permits the visual inspection and a culling out of any subassemblies which may be defective, before final assembly within the tubular holder 4.

In building the fuse, the interrupter and indicator subassemblies, to be hereinafter described, are combined and the lower ferrule press-fitted into place. The glass melamine tube is next inserted into the ferrule and the entire assembly filled with sand. The granular size of the silica sand filler is of greater significance at minimum current interruption than at high currents. An optimum grain size was found which proved to be more effective in interrupting currents at full voltage than did either a more coarse or finer sand. Assurance of an adequate and compact sand filling is attained by the use of a vibrator-filler which completely fills the fuse, except for the indicator, with a high-purity, silica sand. The top ferrule is next fitted over the tube and press-fitted to the proper end studs. Final soldering of the ferrule-stud connection is followed by a baking operation which cures the cement used between ferrules and the glass melamine tube. The fuse is then ready for final inspection and a resistance check for quality control purposes.

In order to provide a visual indication of fuse operation, there is provided a fuse operation indicator at one end of the fuse tube 4 and indicated generally at 17. The operation indicator comprises a tubular housing 18 having a shoulder 19 at one end abutting the terminal disc 11 and having a tubular portion extending beyond the shoulder 19 within the previously described centralized aperture in the terminal plate 11. The opposite end of the housing 18 is open and extends outwardly of plate 11 into abutting relationship with the inside edge of an aperture 20 in the end cap 6, the aperture 20 having a diameter slightly smaller than the inside diameter of the tubular housing 18 for reasons which will be immediately apparent. Slidably mounted within the housing 18 is a cylindrical plastic indicator 21 having a diameter slightly less than the diameter of aperture 20 and having a flange portion 22 at the inner end thereof having a diameter

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substantially the same as that of the inside of housing 18 and greater than the diameter of aperture 20 in the end cap 6. The length of the cylindrical indicator 21 is such that it may be fully enclosed within the housing 18 thus indicating the absence of fuse operation. A compression spring 23 is mounted in the housing between the shoulder 19 of the housing 18 and the flange 22 of the indicator 21 to bias the indicator 21 outwardly of the housing 18 whereupon the flange 22 engages the inside edge of aperture 20, thus indicating the operation of the fuse by the extension of indicator 21 outwardly of the housing 18 into view of an inspector.

Normally, the indicator 21 is held within the housing 18 out of the view of the inspector by means of a fusible conductor 24 fixed to an upper stud 12 and extending down through the central aperture of tubular support rod 8, through the centralized aperture of terminal disc 11, through the tapered neck opening 25 of housing 18, an eye 26 on the inner end of indicator 21, back through the tapered opening 25 and between the shoulder 19 and the bottom side of the plate 11. A tapered plug 27, comprised of insulating material, is tightly fitted in the tapered opening 25. Thus, the wire 24 is pressed into electrical conducting relationship with the metal plate 11 when the fuse is assembled, and the plug 27 serves as an anchor for the end of conductor 24 to hold the indicator 21 in the retracted position against the biasing action of spring 23. In operation, when the main fusible elements 15 operate, an increased current is passed through conductor 24 causing it to fuse, thus releasing the indicator 21 which extends outwardly of housing 18 under the biasing force of spring 23. Inasmuch as the lower looped portion of conductor 24 extending between the plug 27 and eye 26 is in air rather than in an arc extinguishing insulating means 16, as is the remaining portion of the conductor 24, the described loop portion fuses first rather than the remaining portion of the conductor 24 to thus effect release of the indicator 21.

From the foregoing description, it will be seen that there has been provided a new fuse particularly adaptable to motor starting duty, if desired, in that it satisfies high voltage motor starting requirements. The fuse interrupts fault currents without noise or display. The problem of element damage associated with heavy current fluctuations of motor starting has been solved by the introduction of fatigue proof fusible elements.

Having described a preferred embodiment of the invention in accordance with the patent statutes, it is desired that the invention be not limited to this particular structure, inasmuch as it will be obvious to persons skilled in the art that many modifications and changes may be made in this particular structure without departing from the broad spirit and scope of this invention. Accordingly, it is desired that the invention be interpreted as broadly as possible and that it be limited only as required by the prior art.

I claim as my invention:

1. A fuse, comprising: a tubular fuse holder; spaced terminal means in said holder; elongated fusible conductor means of the flat ribbon type connected between said terminal means; said fusible conductor having portions each prebent at an obtuse angle at a plurality of equally spaced points along substantially its entire length to distribute flexing of the fusible conductor among the vertices of the angles to limit the stress at any one point of said fusible conductor means and prevent a fatigue failure when the fusible conductor expands and contracts under changing load; and arc quenching means surrounding the fusible means in said holder.

2. A fuse, comprising: a tubular fuse holder; spaced terminal means in said holder; a plurality of elongated fusible conductors of the flat ribbon type connected in parallel between said terminal means; each of said fusible conductors having portions each prebent at an obtuse angle at a plurality of equally spaced points along sub-

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stantially its entire length to distribute flexing of the fusible conductor among the vertices of the angles when the fusible conductor expands and contracts under changing load, each of said portions including substantially planar portions meeting at said obtuse angle; and insulating means surrounding the fusible means.

3. A fuse, comprising: a tubular fuse holder; spaced terminal means in said holder; elongated fusible conductor means of the flat ribbon type connected between said terminal means; said fusible conductor being prebent to form obtuse angles in a uniformly zig-zag manner along substantially its entire length to distribute flexing of the fusible conductor among the various vertices of the angles when the fusible conductor expands and contracts under changing load, said obtuse angles being formed by the meeting of substantially planar portions of said fusible conductor means; and insulating means surrounding the fusible means.

4. A fuse, comprising: a tubular fuse holder, spaced terminal means in said holder; an elongated flat fusible conductor having periodically spaced restricted portions along its length and connected between said terminal means; said fusible conductor being prebent to form obtuse angles in a zig-zag fashion across the plane of the flat conductor at the restricted portions along its length to distribute flexing of the fusible conductor among the various vertices of the angles to limit the stress at any one point of said fusible conductor and prevent a fatigue failure at one point of said fusible conductor when the fusible conductor expands and contracts under changing load; and insulating means surrounding the fusible means.

5. A fuse, comprising: a tubular fuse holder; spaced

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terminal means in said holder; an elongated fusible conductor connected between said terminal means; said terminal means comprising massive conductor means for absorbing heat from the fusible conductor means during low overcurrent conditions; said fusible conductor being of the flat ribbon type and having portions prebent at an obtuse angle at a plurality of spaced points along its length to distribute flexing of the fusible conductor among the various vertices of the angles when the fusible conductor expands and contracts under changing load, said points being spaced along substantially the entire length of said fusible conductor at equal intervals, said obtuse angle being substantially 120°; and arc quenching means surrounding the fusible means in said holder.

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