

[54] **QUICK ACTING HIGH VOLTAGE FUSE**

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[58] Field of Search 337/158, 159, 161, 290, 337/293, 295

[56] **References Cited**

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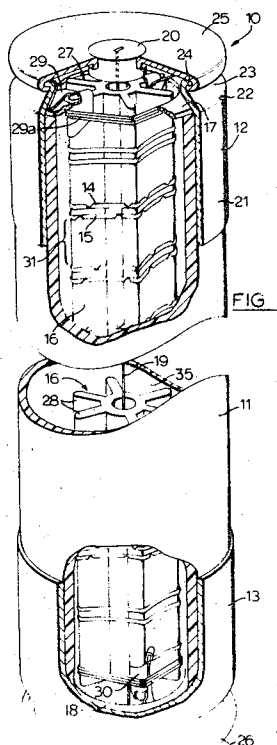
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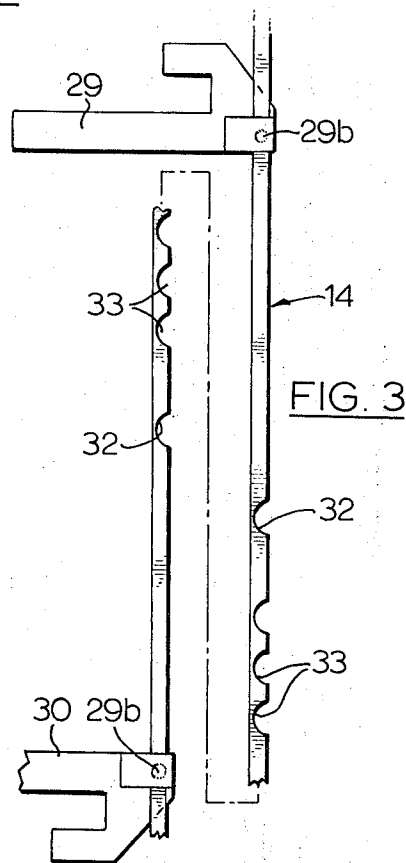
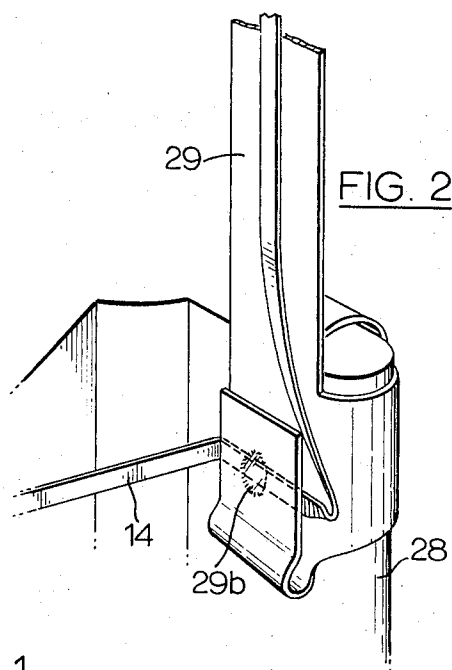
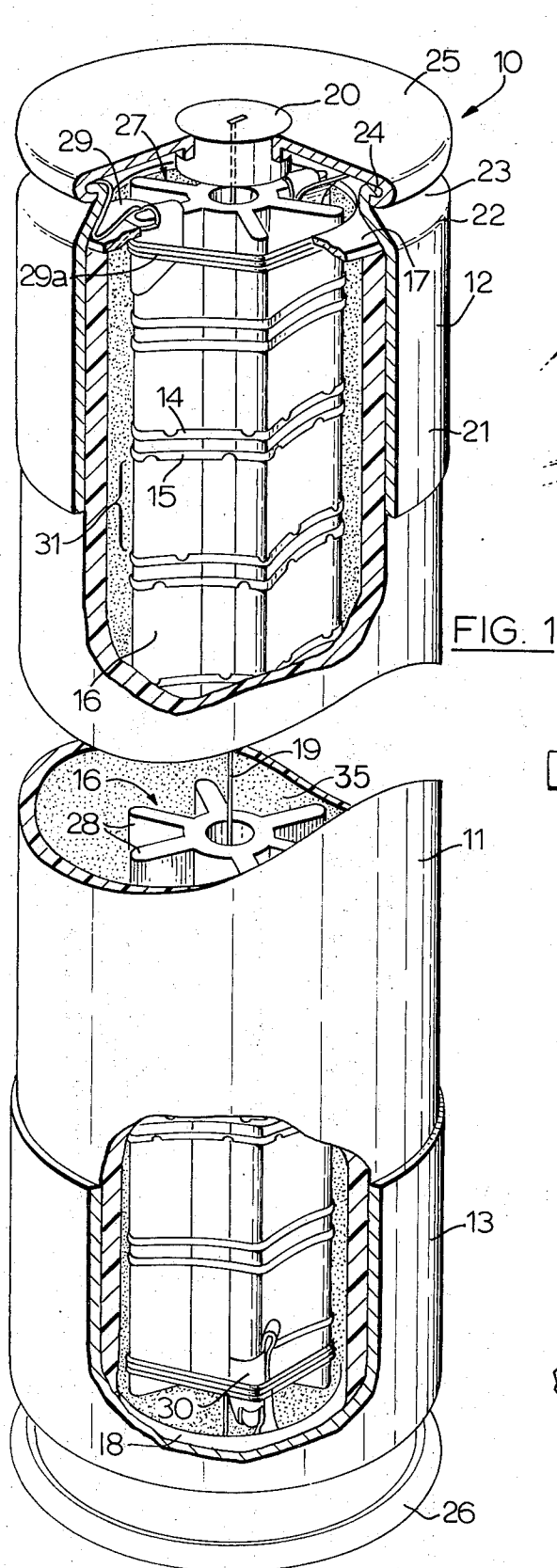
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[57] **ABSTRACT**

A quick acting current limiting, high voltage fuse comprising a tubular casing made of an insulating material; one or more relatively long fusible elements wound helically on an insulating core which is located inside the casing coaxially therewith; a pair of metallic terminals which close the ends of the casing and are connected to the ends of the fusible elements; and a granular arc extinguishing material which completely fills the casing and embeds the elements and core. Each element consists of a very thin, narrow and long strip of a fusible metal such as silver having along its length in one edge a plurality of spaced notches made by cutting out small segments of strip. Each notch appears in outline on the flat side of the strip as an arc of a circle. These notches define regions of reduced cross section for initiating fusion of the strip. Their configuration and arrangement reduces the tendency of the arcs to run together as they enlarge. Their presence also produce a rapid rise in arc voltage, short melting time, and low I²t.

3 Claims, 3 Drawing Figures





QUICK ACTING HIGH VOLTAGE FUSE

This invention relates to a relatively high voltage, low current fuse which has one or more ribbon-type fusible elements capable of interrupting with low I^2t . This particular type of fuse is well suited for protecting capacitors used for power factor correction and other purposes in a power supply, in particular capacitors of the higher voltage ratings.

The following published art, now known to applicant, are exemplary of prior art approaches relevant in this area of technology: U. S. Pat. Nos. 2,703,352-Kozacka; 2,886,037-Stewart; 3,007,019-Kozacka; 3,294,936-Mikulecky; British Pat. No. 978,493; and Canadian Pat. Nos. 690,991; 741,422; 779,424.

In a bank of power capacitors, it is important that a capacitor which has developed a short circuit be removed from the line very quickly before it bursts. This requires fuses with a short melting time and high arc voltages. Fuses constructed according to the invention are for this purpose, or other applications where rapid fusing with limited energy input is necessary.

The overall construction of a fuse according to the invention consists of the following: A tubular casing made of an insulating material; one or more relatively long fusible elements wound helically on an insulating core which is located inside the casing coaxially therewith; a pair of metallic terminals which close the ends of the casing and are connected to the ends of the fusible elements; and a granular arc extinguishing material which completely fills the casing and embeds the elements and core. Each element consists of a very thin, narrow and long strip of a fusible metal such as silver having along its length in one edge a plurality of spaced notches made by cutting out small segments of strip. Each notch appears in outline on the flat side of the strip as an arc of a circle. These notches define regions of reduced cross section for initiating fusion of the strip. Their configuration and arrangement reduces the tendency of the arcs to run together as they enlarge. Their presence also produce a rapid rise in arc voltage, short melting time, and low I^2t . In this expression I is current and t is time.

A better understanding of the invention may be had from the description to follow taken with the accompanying drawings, in which:

FIG. 1 is a perspective view of a fuse constructed according to the invention;

FIG. 2 is a view of a terminal structure used in the fuse of FIG. 1; and

FIG. 3 is a view of a fusible element.

In FIG. 1, there is shown a high voltage, low current fuse 10 suitable for use in the protection of power capacitors and other loads of this nature. Fuse 10 has a tubular casing 11, a pair of end terminals 12 and 13, two fusible elements 14 and 15 wound helically on a hollow ceramic core 16, and connected to terminals 12 and 13 respectively, a pair of discs 17 and 18 for supporting core 16 coaxially with respect to casing 11, a high resistance element 19 passing through the hollow of core 16 and connected to terminals 12 and 13 respectively, a granular arc extinguishing material 35 completely filling the enclosure defined by casing 11 and terminals 12, 13, and a device 20 actuated by element 19 for indicating that the fuse has blown. Casing 11 is a relative long tube made of a strong, hard, heat resistant, electrical insulating material such as mat of

glass fibers bonded together with a polyester resin. Terminal 12 has a relatively long skirt 21 which is an interference fit over the upper end of the casing, an inwardly formed shoulder 22, a short neck 23, and an outwardly flared end 24 closed by a cap 25 which has its outer edge rolled over the flared end and is adapted for supporting indicating device 20. The terminal, including its end cap, is made of a conductive metal such as copper and the regions where it makes contact with the fuse holder may be silver plated to ensure that a good electrical connection is made between the terminal and holder. Terminal 13 is exactly the same as terminal 12 except that its end cap 26 is plain, and it is pressed onto the lower end of the casing in the same way that terminal 12 is pressed onto the upper end of the casing.

Discs 17 and 18 are alike, and are flat, circular members made from a strong, hard, heat resistant electrical insulating material such as a mat of glass fibers bonded together with a melamine resin. In addition to providing support for core 16, discs 17 and 18 also serve as shields for keeping the arc from running into the ends of terminals 12 and 13. Disc 17 is fitted inside the skirt of terminal 12 at the upper end of casing 11, and is secured to these components by having its outer edge wedged between the end of the casing and the shoulder 22 on the terminal. Disc 18 is secured to the lower end of the casing and terminal 13 in exactly the same way. Each disc, as particularly indicated for disc 17, has a large central opening 27 for receiving an end of core 16.

Core 16 is a long ceramic tube having a number of high ridges 28 on its periphery running lengthwise of the tube coaxially therewith. The core is a little longer than the distance between discs 17 and 18 so that its ends extend a little way through the openings in the discs, and it is slender enough that a significant radial space is left between it and the wall of the casing. The discs position the core coaxially within casing 11 and metal tabs 29, 30 secure the core against axial movement. There is usually more than one tab 29, and each one has one end attached to the core and the other end clamped between cap 25 and skirt 21 between the roll over connection at 24. Each one of the tabs 29 is clipped onto the upper end of a core ridge and secured there by a band 29a. Tabs 30 provide the same kind of support for the other end of the core on terminal 13.

Fusible elements 14 and 15 are thin, narrow, and long strips of a fusible metal such as silver. Although two elements are illustrated, more than this may be used, all being placed in parallel between terminals 12 and 13. They are wound flatwise into a helix around core 16 as shown in FIG. 1 with adjacent strip edges relatively close together and with much greater spacing 31 between the turns of the helix. The upper end of the helix ends below disc 17 and the lower end above disc 18. An end portion of each strip extends above disc 17 in between the flared end 24 of terminal 12 and its end cap 25 where the ends are firmly secured to the terminal structure, these ends having been brought out over the flared terminal end before the cap is applied. Since the ends of the strips are squeezed between the flared surface and the rolled edge of the cap, a good electrical connection is, therefore, made between the ends of the strips and the terminal. The other ends of the strips extend below support means 18 and are secured to termi-

nal 13 in exactly the same way. The ends of the strips are also secured to the respective core securing tabs 29 and 30 as indicated by spot weld 29b. In some fuses, the strips may also be welded to terminals 12 and 13 for even better connections.

Fuses of this type usually include a fusible element such as 19 which is of much higher resistance and fusing temperature than elements such as 14, 15. This element passes through the hollow in core 16 from one terminal to the other. It introduces resistance into the circuit as elements 14, 15 blow, and immediately after all the elements 14, 15 have blown, it also blows and triggers the indicating device 20 into displaying a flag which gives a visual indication that the fuse has blown. This feature is well known in the art.

The granular arc extinguishing material 35 may be a sand well known in the art for its arc quenching properties. The fuse is completely assembled except for cover 26 before it is filled with the sand. To apply the sand, the fuse is placed upright with its closed end down, the reverse of that illustrated in FIG. 1, and vibrated while dry sand is poured into it through its open end. After all the spaces inside the enclosure defined by casing 11 and terminals 12 and 13 are completely full of sand and the fusible elements well embedded therein, cover 26 is applied to complete the assembly.

The novel fusible elements 14 and 15 will now be described. As already pointed out, there may be more than the two elements identified at 14 and 15. However, as they are all similar in configuration only one, that identified by numeral 14, will be described. The elements are placed in a like manner on the core so that the parallel circuit formed by the elements is balanced both electrically and mechanically.

Fusible element 14 is a very thin, narrow, and long strip of a fusible metal such as silver wound on one flat side into a number of turns around core 16. In order to initiate fusion of the strip at specific points along its length, the cross section of the strip is reduced at these points. The reductions in cross section illustrated at FIG. 3 consists of portions 32, 33 cut out of the strip along one edge thereof. Each cut-out appears as an arc of a circle on the side of the strip and extends into the strip from the same edge thereof. The first notch 32 at each end of the strip is spaced quite some distance from the core securing tabs 29 and 30 and a somewhat lesser distance from notches 33 which are spaced much closer together at approximately equal intervals along the intervening length of the strip. When more than two strips are used, preferably, the strips will be wound on the core with the notches facing in the same direction.

Fusible elements of the configuration illustrated at 14 and applied in a structure of the kind described are found to have good rupture characteristics. A helical arrangement of elements such as this give the elements enough length that a relatively short fuse casing can be used with relatively high voltages. When the fuse blows, the series of restricted cross sections fuse to provide a series of arcs, the sum of which produce a high arc voltage. This fuse is well suited for use in protecting high voltage equipment, for example, power capacitors, in that it will melt and clear at low I^2t and rapidly rising arc voltages. Its response to fault currents is fast enough that it will remove the capacitor from the line well before it bursts in the event the capacitor develops a short circuit.

By placing the notches along only a first edge of the strip, the lateral movement of all of the arcs tends to take place in the same direction from the longitudinal centerline of the strip. This arrangement of the notches also reduces the tendency for the arcs to run together as they enlarge, and it produces a rapid rise in arc voltage, short melting time, and low I^2t . A rapid rise in arc voltage associated with a short melting time, and a low I^2t gives reliable protection for capacitors. Coiling the strips around a ridged core places the notches where the sand is effective in dissipating the heat from the arcs. This leads to a favorable temperature gradient inside the fuse during normal operation and during arcing.

By way of example to demonstrate the actual working of the invention, fuses are now available of voltage ratings in the order of 14,400 to 15,500 volts and current ratings in the order of 10 to 12 amperes per element. Each element is a strip of silver having a width in the order of 0.035 inches, a thickness in the order of 0.005 inches, and an effective length in the order of 55 inches. The two notches 32 at the ends of the strip are located approximately $9\frac{1}{2}$ inches from tabs 29, 30 and approximately 2 inches from the array of notches 33 along the intervening length of strip. Notches 33 are spaced apart approximately five-eighths inch. Each one of the notches is cut from one edge of the strip on an arc of a circle having a radius 0.047 inches. The width of the strip left at the base of the notch at the narrowest point is in the order of 0.009 inches.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects; and I, therefore, intend herein to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. A quick acting fuse comprising:
 - a. a tubular casing;
 - b. a terminal structure closing each end of the casing;
 - c. a core located inside said casing coaxially therewith, said core being slender enough that a significant radial space is left between it and said casing;
 - d. at least one fusible element wound helically on said core with the turns of the helix spaced from one another, said element having its ends connected to the respective terminal structures, said element comprising:
 - i. a relatively long strip of fusible conducting material having a plurality of notches along its length, the first notch in each end of said strip is spaced a significant distance from the respective terminal structure and a somewhat lesser distance from the next adjoining notch and the remaining notches are spaced even closer together at approximately equal intervals; and
 - e. a granular arc extinguishing material filling the casing and embedding the fusible element.
2. The quick acting fuse as specified in claim 1 wherein a plurality of said strips are wound flatwise on said core in parallel and spaced relatively close to one another and with a much greater spacing left between the turns of the strip.
3. The quick acting fuse as specified in claim 6 wherein the notches in each of said strips are all located along only one edge of the strip and said strips are so wound on said core that all of their notches face in the same direction.

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