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TERMINAL MEANS FOR FUSIBLE ELEMENT OF CURRENT LIMITING FUSE

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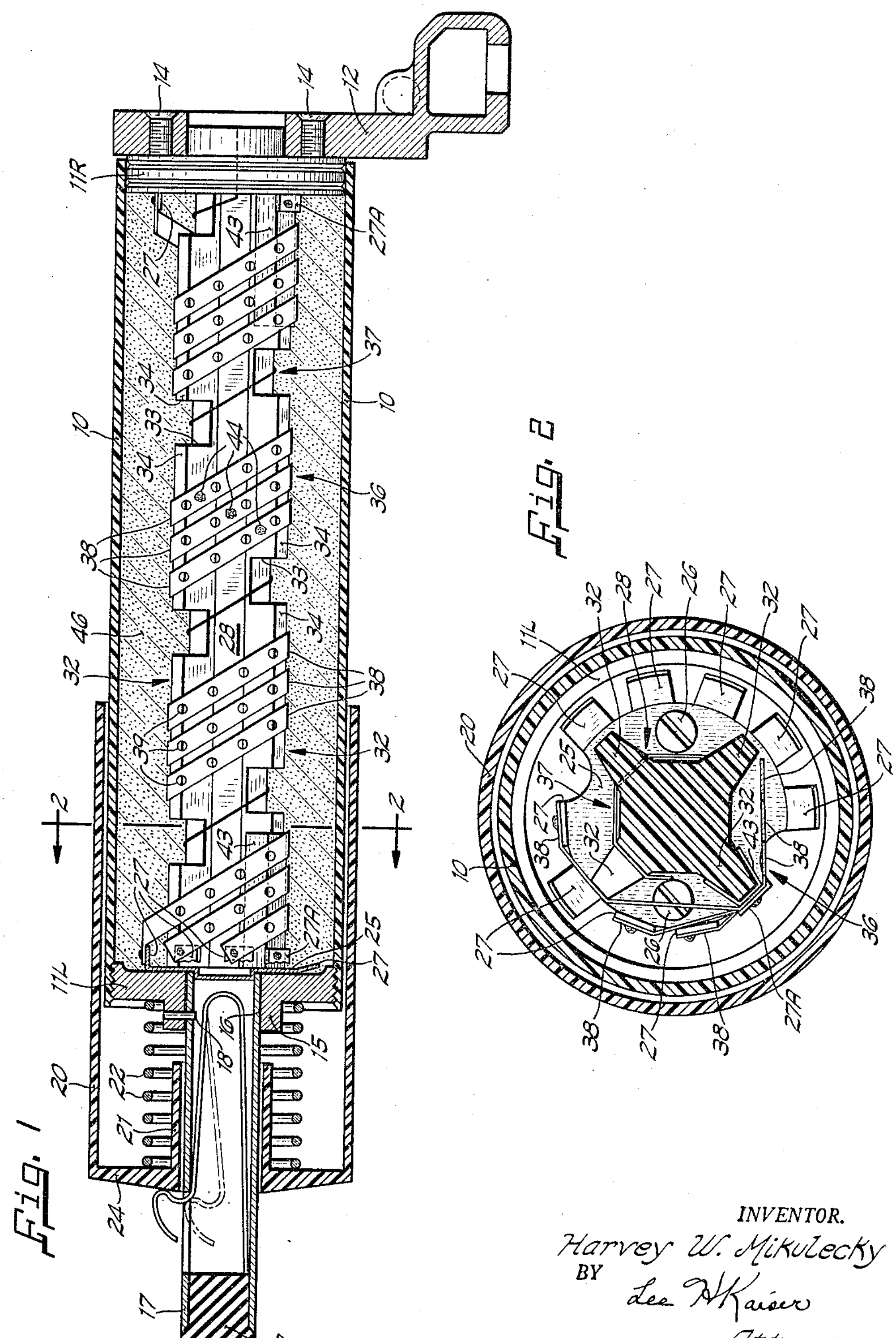

INVENTOR.
Harvey W. Mikulecky
BY Lee H. Kaiser
Attorney

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TERMINAL MEANS FOR FUSIBLE ELEMENT OF CURRENT LIMITING FUSE

Harvey W. Mikulecky, Racine, Wis., assignor to McGraw-Edison Company, Milwaukee, Wis., a corporation of Delaware

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This invention relates to electrical fuses and, more particularly, to fuses of the current limiting type which limit the flow of current in a circuit to a substantially smaller magnitude than the available fault current of the circuit.

Current limiting fuses usually open with such speed that the fuse arc resistance is introduced during the first half cycle of the short circuit current, and the actual "let-through" current is reduced to much less than the available current which would flow in the circuit if the fusible element were intact. Current limiting fuses conventionally comprise a fusible element embedded in a granular inert material of high dielectric strength such as sand or finely divided quartz. Usually the fusible element is in the form of one or more thin conductors of silver wound on a supporting core, or spider, of high temperature resistant ceramic material. As fault current begins to flow the element melts and an arc is formed. When subjected to current of high magnitude, the fusible element attains fusing temperature and vaporizes almost instantaneously, whereupon arcing occurs along the entire length of the element and the metal vapors rapidly expand to many times the volume occupied by the fusible element and are thrown into the spaces between the granules of inert filler material where they condense and are no longer available for current conduction. The physical contact between the hot arc and the relatively cool granules causes a rapid transfer of heat from the arc to the granules, thereby dissipating most of the arc energy with very little pressure buildup within the fuse enclosure. Consequently, a high resistance is, in effect, inserted into the path of the current and initially limits the current to a magnitude which is only a small fraction of that available in the circuit. The inserted resistance increases rapidly and results in rapid decay of current and subsequent interruption of current with negligible generation of gas and noise. The sand particles in the immediate vicinity of the arc fuse and become partial conductors at the high temperature of the arc. The fused particles cool upon extinction of the arc and solidify into a "fulgurite," which is in the nature of a glass body, and lose their conductivity and become insulators as they cool.

Unlike expulsion fuses, current limiting fuses are designed to operate within a specific range of voltages. Each voltage size of current limiting fuse is designed to operate over its entire fault capacity range with a "permissible" transient voltage surge. Each size of current limiting fuse must be designed so that this "permissible" peak arc voltage stays well below the basic impulse level of the power system and below the sparkover potential of lightning arresters on the power system, and careful choice must be made of the number and size of the silver wires or silver ribbons which comprise the fusible element to assure proper clearing of the fuse from minimum melting current to maxium rating thereof.

High amperage current limiting fuses often comprise a number of conductors such as silver ribbons helically wound in parallel on the insulating spider and electrically connected between the end terminals of the fuse. Each silver conductor rapidly vaporizes under high fault current, and a fulgurite is formed along the entire length of the conductor. The arcs within the individual fulgurites tend to assume the shortest path between the end terminals of the fuse and to merge together adjacent the end terminals because the path from conductor-to-conductor in an axial direction is shorter than the helical path along the conductor. As a consequence, the individual arcs do not continue along the entire length of the individual conductors but rather concentrate in a single fulgurite adjacent the fuse end terminals. This heavy concentration of arc heating in a single fulgurite adjacent the fuse end terminals often scorches the fuse casing and can result in release of hot gases, flashover of the fuse, or mechanical failure of the fuse.

It is an object of the invention to provide a high amperage current limiting fuse construction which prevents scorching of the fuse casing, flashover of the fuse, and mechanical failure of the fuse caused by excessive arc heating.

This and other objects and advantages of the invention will be more readily apparent from the following detailed description when taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a partial longitudinal view through a current limiting fuse embodying the invention; and

FIG. 2 is a view taken on line 2—2 of FIG. 1.

Referring to the drawing, a tubular enclosing casing **10** for a current limiting fuse is constructed of suitable insulating material such as glass, fiber, or glass fiber impregnated with epoxy resin. A metallic end piece **11R** may be secured to the right end of casing **10** by means of any suitable seal such as epoxy cement, and a metallic end piece **11L** may have external threads engaging internal threads near the left end of casing **10** to affix end piece **11L** to casing **10**. A metallic hinge assembly **12** may be secured to the end piece **11R** at the right end of fuse casing **10** by screws **14** engaged within threaded apertures in the end piece **11R**. The end piece **11L** has a smaller diameter tubular portion **15** and an axial bore **16**. A tubular metallic terminal member **17** extends into axial bore **16** with a force fit and is rigidly secured to end piece **11L** by pins **18** extending radially through terminal member **17** and smaller diameter portion **15** of end piece **11L**. Terminal member **17** is adapted to fit within a stationary jaw contact (not shown) of an electrical switch, and an insulating member **19** provided with an eye (not shown) for receiving a hook-stick may be secured in the end of tubular member **17** by suitable means such as epoxy cement. An arc extinguishing sleeve member **20** slidably fitting over casing **10** may have an inner tubular portion **21** of insulating material telescoped over terminal member **17** and be urged axially into covering relation with terminal member **17** by a helical spring **22** compressed between end piece **11L** and the end portion **24** of arc extinguishing member **20** for the purpose of interrupting any arc formed between terminal member **17** and the switch jaw contact as described in my copending application Serial No. 298,882 filed July 31, 1963 and having the same assignee as this invention.

Metallic end plates **25** are disposed against the internal surface of end pieces **11L** and **11R** and are secured thereto by screws **26**. Each end plate **25** has a plurality of radially extending tabs **27** adjacent its outer periphery which may be bent down and form terminals to which the fusible conductors may be electrically connected. An elongated insulating core, or spider, **28** is axially mounted within casing **10**. The ends of spider **28** are affixed to metallic end plates **25** by suitable means such as epoxy cement.

Spider **28** is of generally star-shaped cross section and has a plurality of radially protruding, peripherally spaced apart, longitudinally extending fins **32**. Each fin **32** has a plurality of depressions **33** spaced apart longitudinally of spider **28** and forming longitudinally spaced apart, raised shoulders **34** on each fin. The depressions **33** of peripherally successive fins are progressively staggered in a longitudinal direction of spider **28** so that the peripherally successive depressions **33** define a continuous helical path and the peripherally successive raised shoulders **34** form support means of helical configuration for a helically wound circuit interrupting element **36** interconnecting the end pieces **11L** and **11R**. A fusible wire **37** for indicating operation of the fuse may be disposed in the continuous helical path defined by the depression **33**.

Spider **28** may be of a heat resistant ceramic insulating material such as porcelain, but in the preferred embodiment of the invention spider **28** is of an electrical insulating material adapted to evolve gas in the presence of an arc and may be of a molded thermosetting composition comprising a water insoluble binder and an anti-tracking substance selected from the class consisting of the hydrates and oxides of aluminum and magnesium as disclosed in my copending application Serial No. 313,640 filed October 3, 1963 entitled Current Limiting Fuse and having the same assignee as the subject invention. The composition of spider **28** may also include other fillers such as mica, glass fiber, asbestos, or silica, and one suitable material comprises approximately 60 percent aluminum hydrate filler, 20 percent melamine resin binder, and approximately 20 percent asbestos. The active gas generating and anti-tracking ingredient may be commercial grade aluminum hydrate $Al(OH)_3$, magnesium hydrate $Mg(OH)_2$, an oxide of aluminum such as alumina Al_2O_3, or magnesium oxide. In addition to or in place of the melamine resin, other resins may be employed as the binder of the molding composition, for example, phenolic, urea, polyester or silicone resin.

The casing **10** is filled with a body of suitable pulverulent refractory arc quenching material **46** such as quartz sand so that the spider **28** and the fusible element **36** are directly embedded in the quartz sand filler.

Fusible element **36** is illustrated in the high amperage current limiting fuse shown in the drawing as comprising three silver ribbons **38** helically wound in parallel, spaced apart relation on the raised shoulders **34** so as to be in approximate line contact with fins **32** and touch only peripherally spaced apart points on spider **28**. Ribbons **38** may be secured at their ends by suitable means such as solder to bent-down tabs **27** on the end plates **25** which are affixed to the end pieces **11L** and **11R**. The silver ribbons **38** may have a plurality of circular perforations, or holes, **39** spaced apart along the length thereof which determine the points where fusion of the ribbon is initiated when the fault current and its rate of rise are high. The perforations **39** form portions of reduced cross sectional area so that each ribbon **38** has a number of serially related portions of relatively small cross sectional area and intermediate portions of relatively large cross sectional area. Beads **44** of low melting temperature alloy such as tin-lead solder are in intimate contact with the silver ribbons **38** preferably adjacent the midpoint thereof. At melting currents flowing for prolonged periods, the fusible ribbons **38** become hot enough to melt the alloy bodies **44**, and the amalgamation of the silver and alloy causes a hot spot with high enough resistance to melt the ribbons **38** at this point. This construction, known as the "M" effect, allows the fusible ribbons **38** to melt at a temperature in the 400°–600° F. range, when subjected over a long period of time to low magnitude currents, as compared to the 1760° F. melting temperature for pure silver.

On fault currents of high magnitude, the alloy element **44** has little or no effect, and the silver ribbons **38** vaporize almost instantaneously at the fusion temperature for silver and form fulgurites along the entire length of the ribbons **38**. The arcs within the individual fulgurites tend to assume the shortest path between the metallic end plates **25**, and the fulgurites tend to merge together adjacent the end plates because the parallel, side-by-side arrangement of the silver ribbons **38** results in the path from ribbon-to-ribbon in an axial direction being shorter than the helical path along the ribbon. Consequently, the individual arcs do not continue along the entire length of the individual ribbons **38** but rather concentrate in a single fulgurite adjacent the metallic end plates **25**. This heavy concentration of arc heating in a single fulgurite often scorched the casing **10** of prior art fuses and can burn through the casing and release hot gases which, in turn, can ignite the casing **10** or bridge between the end pieces **11L** and **11R** and flashover the fuse. In embodiments wherein casing **10** is of glass or ceramic material, the intense concentration of arc heating occasionally cracked the fuse casing and caused mechanical failure of the fuse.

In accordance with the invention, an elongated metallic clip **43** of U-shaped cross section extending in a direction parallel to the axis of the fuse is disposed over a raised shoulder **34** at each end of spider **28** in abutting relation to end plate **25** and in a position wherein the three helical silver ribbons **38** are wound in axially spaced apart relation over the longitudinally extending clip **43**. One of the radially extending tabs **27A** on end plate **25** is bent down and soldered to clip **43** so that clip **43** is connected electrically to the end plate **25** and end piece **11**. When a high magnitude fault current vaporizes the silver ribbons **38**, the arcs formed along the ribbons terminate on the longitudinally extending metallic clips **43** rather than on the end plates **25**. Inasmuch as clips **43** extend in an axial direction, no fulgurite-to-fulgurite path in an axial direction exists adjacent the fuse terminals which is shorter than the path along the ribbons, and the individual ribbon fulgurites thus terminate on the clips **43** and have no tendency to merge together or concentrate at a single point. The disclosed construction prevents concentration of the arc and excessive arc heating which in prior art fuses often scorched the fuse tube and released hot gases that flashed over the fuse tube.

On low magnitude faults, the gas generated by the material of spider **28** at the points of contact with fusible ribbons **38** is blown into the arc stream and cools the fulgurite and produces a deionizing action on the arc products so that the inert sand particles quickly lose their conductivity and become conductors.

While only a single embodiment of the invention has been illustrated and described, many modifications and variations thereof will be readily apparent to those skilled in the art, and consequently it is intended to cover in the appended claims all such modifications and variations which fall within the true spirit and scope of the invention.

I claim:

1. In a high amperage current limiting fuse, a tubular insulating casing, an inert granular material of high dielectric strength within said casing, an insulating spider extending parallel to the axis of said casing and embedded in said inert granular material and having peripherally spaced apart, radially protruding portions extending longitudinally thereof, a plurality of silver ribbons helically wound in parallel spaced apart relation on said radially protruding portions of said spider and being embedded in said granular inert material, and a metallic terminal on each end of said casing, said metallic terminals each including a portion extending axially with respect to said casing and engaging said ribbons, said ribbons engaging and electrically connected to said axially extending portions at points spaced axially thereon with respect to said casing so that all of the arcs formed upon vaporization of said ribbons, incident to high magnitude fault current carried by said fuse, terminate on said axially extending terminal portions and do not tend to merge together and cause excessive arc heating.

2. In a high amperage current limiting fuse, a tubular insulating casing, an inert granular material of high dielectric strength within said casing, an insulating spider extending parallel to the axis of said casing and embedded in said inert granular material and having peripherally spaced apart, radially protruding portions extending longitudinally thereof, a plurality of silver ribbons helically wound in parallel spaced apart relation on said radially protruding portions of said spider and being embedded in said granular inert material, each of said ribbons having a body of low melting temperature alloy in contact therewith, said radially protruding portions along at least the surface thereof in contact with said silver ribbons being of an electrical insulating material adapted to generate gas in the presence of an arc and being capable of continuously withstanding temperatures up to 250° F. without degradation and up to 500° F. for periods of up to one hour without substantial decomposition, and a metallic terminal on each end of said casing and electrically connected to all of said ribbons, said metallic terminals including a portion extending axially with respect to said casing across the helical path of and electrically connected to all of said ribbons, said ribbons engaging and electrically connected to said axially extending portions at points spaced axially thereon with respect to said casing so that all of the arcs formed upon vaporization of said ribbons, incident to high magnitude fault current carried by said fuse, terminate on said axially extending terminal portions and do not tend to merge together and cause excessive arc heating.

3. In a fuse in accordance with claim **2** wherein said insulating material includes a water insoluble binder and an anti-tracking substance selected from a group consisting of the hydrates and oxides of aluminum and magnesium.

4. In a high amperage current limiting fuse, a tubular insulating casing, an inert granular material of high dielectric strength within said casing, an insulating spider extending parallel to the axis of said casing and embedded in said inert granular material and having peripherally spaced apart, radially protruding portions extending longitudinally thereof, a plurality of silver ribbons helically wound in parallel spaced apart relation on said radially protruding portions of said spider and being embedded in said granular inert material, a metallic terminal on each end of said casing having a plurality of circumferentially spaced apart portions individually affixed to said helically wound ribbons and also having a portion extending axially with respect to said casing across the helical path of and electrically connected to all of said ribbons at points spaced axially thereon with respect to said casing so that, all of the arcs formed upon vaporization of said ribbons terminate on said axially extending terminal portions and do not tend to merge and to cause excessive arc heating.

5. In a fuse in accordance with claim **4** wherein said spider is of an insulating material capable of generating gas in the presence of an arc and each of said ribbons has a body of low melting temperature alloy in contact therewith.

6. In a fuse in accordance with claim **5** wherein said insulating material includes a water insoluble binder and an anti-tracking substance selected from a group consisting of the hydrates and oxides of aluminum and magnesium.

7. In a high amperage current limiting fuse, a tubular insulating casing, an inert granular material within said casing, an insulating support core extending parallel to the axis of said casing and embedded in said inert granular material, a plurality of fusible elements helically wound in generally parallel spaced relation on said support core and embedded in said inert granular material, and a metallic terminal at each end of said casing, said metallic terminals each including a portion extending axially with respect to said casing and engaging said fusible elements, said fusible elements engaging and electrically connected to said axially extending portion at points spaced axially thereon so that all of the arcs formed upon vaporization of said fusible elements terminate on said axially extending terminal portions at said axially spaced points and do not tend to merge together and cause excessive heating.

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BERNARD A. GILHEANY, *Primary Examiner.*

H. B. GILSON, *Assistant Examiner.*