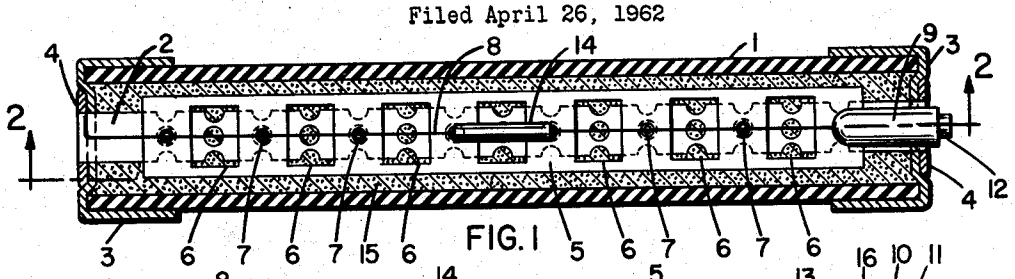
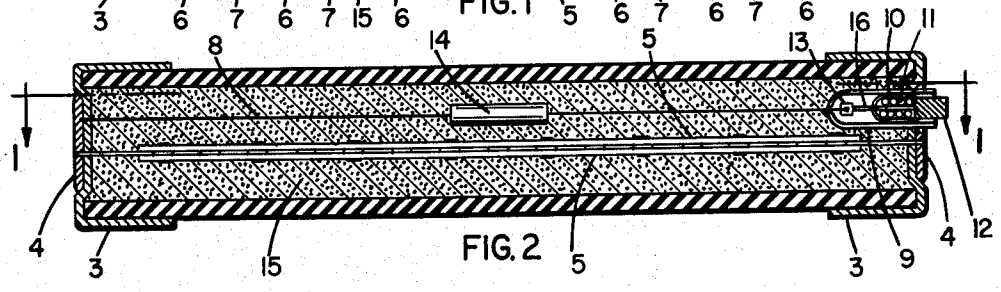
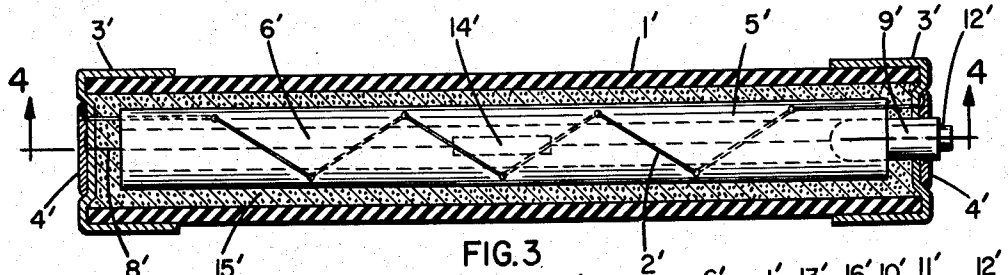
Dec. 3, 1963 P. C. JACOBS, JR 3,113,193

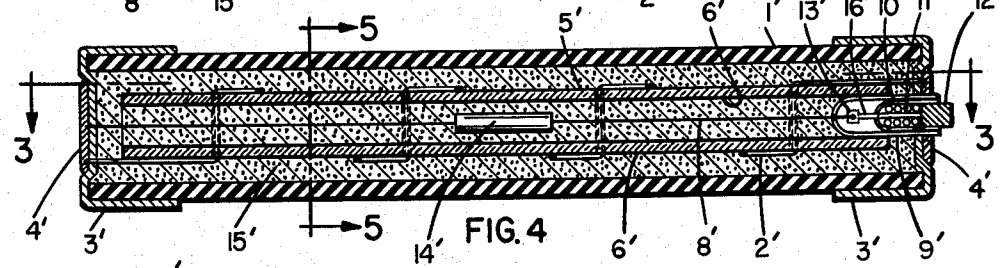
ELECTRIC STRIKER PIN FUSES FOR ELEVATED CIRCUIT VOLTAGES

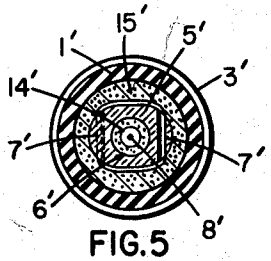
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INVENTOR.
PHILIP C. JACOBS, JR.
BY

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3,113,193

ELECTRIC STRIKER PIN FUSES FOR ELEVATED CIRCUIT VOLTAGES

Philip C. Jacobs, Jr., Newtonville, Mass., assignor to The Chase-Shawmut Company, Newburyport, Mass.

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6 Claims. (Cl. 200—121)

This invention relates to electric fuses, and more particularly to electric fuses for relatively high circuit voltages.

As seen from another point of view this invention relates to electric fuses having striker pin mechanisms. Striker pin mechanisms include striker pins having a restrained position and an unrestrained position. Upon blowing of the fuse the striker pin is released and projected with considerable force to its unrestrained position.

Striker pin mechanisms and blown fuse indicators are generally based on the same principles. They differ from each other in terms of function inasmuch as striker pin mechanisms must be capable of performing a predetermined amount of work—e.g., tripping a circuit breaker—when moving from their restrained position to their unrestrained position. The object of blown fuse indicators is merely to indicate the condition any particular fuse is in, and this does not require any significant amount of work to be performed by an indicator pin of a blown fuse indicator.

If operated by some explosive medium a striker pin can readily be caused to perform relatively large amounts of work. The use of explosive propelling media for operating striker pins involves, however, a number of serious drawbacks and limitations.

It is therefore, one object of this invention to provide electric fuses having striker pin mechanisms adapted to perform relatively large amounts of work without resorting to explosive propelling media.

Spring-propelled striker pins require strong restraining wires if the work to be performed by the propelling spring upon fusion of the restraining wire is to be large. Where the work to be performed by a striker pin ought to be large, the required tensile strength of striker pin restraining wires can only be achieved by using high tensile strength metals, such as steel, for making the restraining wires, and by using restraining wires whose cross-section is relatively large. This results in a number of serious drawbacks. The striker pin restraining wires form a shunt path for the current normally flowing through the fuse link means of an electric fuse. As long as the restraining wire is relatively thin and its resistance correspondingly high, the rate of current flow through such a restraining wire is relatively negligible while the fuse performs its current carrying duty. If the diameter of a restraining wire is relatively large, as required when it is desired to restrain powerful propelling springs for striker pins, then the rate of current flow through such a restraining wire while the fuse performs its current-carrying duty cannot be neglected. Then the current shunted away by the restraining wire from the fuse link means is sufficiently large to change the time-current characteristic of the particular fuse as primarily determined by the geometry of the fuse link means thereof. Restraining wires of steel having a relatively large diameter tend also to impair the interrupting capacity of any given design because substantial fulgurities are generally formed along such restraining wires incident to fusion and backburning of such restraining wires.

It is, therefore, an important object of this invention to provide striker pin fuses having spring-propelled striker pins capable of performing large amounts of work and having steel restraining wires whose diameters are large

and which fuses are not subject to the aforementioned drawbacks normally characteristic of such fuses.

Other objects and advantages of the invention will become apparent as this specification proceeds, and the features of novelty which characterize the invention will be pointed out with particularity in the appended claims forming part of this specification.

For a better understanding of the invention reference may be had to the accompanying drawings in which:

FIG. 1 shows a first embodiment of the invention and is substantially a section along 1—1 of FIG. 2;

FIG. 2 is substantially a section along 2—2 of FIG. 1;

FIG. 3 shows a second embodiment of the invention and is substantially a section along 3—3 of FIG. 4;

FIG. 4 is substantially a section along 4—4 of FIG. 3; and

FIG. 5 is a section along 5—5 of FIG. 4.

Referring now to the drawings, and more particularly to FIGS. 1 and 2 thereof, numeral 1 has been applied to indicate a tubular casing of insulating material, e.g., of a melamine-glass-cloth-laminate, closed on both ends by terminal elements in the form of caps 3. A ribbon fuse link 2 arranged inside of casing 1 conductively interconnects terminal caps 3. The ends of fuse link 2 project through slits in caps 3 to the outer surfaces of caps 3 and are soldered to caps 3 by pools 4 of solidified solder arranged in recesses on the axially outer surfaces of caps 3. Fuse link 2 is sandwiched between a pair of plates 5 of insulating material having rectangular cut-outs 6. The sections of link 2 which are arranged in cut-outs 6 are exposed to the action of arc-quenching sand filler 15, whereas the sections of link 2 which are arranged between contiguous cut-outs are substantially shielded by the sandwiching plates 5 from the action of pulverulent filler 15. Fuse link 2 is provided with a plurality of transverse lines of circular perforations, the region of each other such line being exposed to the action of filler 15 through cut-outs or windows 6. Plates 5 and fuse link 2 are integrated into a structural unit by eyelets 7 projecting through perforations in link 2 covered by plates 5. The diameter of the shanks of eyelets 7 projecting through some of the perforations in link 2 is smaller than the diameter of the perforations through which they project, thus giving plates 5 a limited freedom of motion relative to link 2 within the plane defined by link 2.

Restraining wire 8 is arranged in a plane parallel to the general plane defined by link 2 and plates 5. The left end of restraining wire 8 is threaded through a narrow perforation in left cap 3 and held in position by solidified solder pool 4. Right cap 3 is associated with a pair of coaxial striker pin caps 9 and 10. The radially inner striker pin cap 10 houses the striker pin spring 11 and the striker pin 12 biased by spring 11 from the left to the right. The outer striker pin cap 9 is held in position by solidified solder pool 4. Both striker pin caps 9 and 10 are provided with a narrow perforation on the axially inner end thereof. The right end of restraining wire 8 is threaded through the perforation in outer striker pin cap 9 and secured to abutment tab 13 forming part of a rod 16 attached to striker pin 12. Striker pin rod 16 is free to move inside the perforation in inner striker pin cap 10 through which rod 16 is threaded. Abutment tab 13 can move from its position shown in FIG. 2 to the right, but its travel to the left is limited by outer striker pin cap 13. Restraining wire 8 comprises two portions of which one is arranged to the left, and the other portion is arranged to the right, of resistor 14. Restraining wire or restraining conductor 8 forms a shunt path at least across a portion of fuse link means 3. In the instant case restraining conductor 8 shunts the entire length of fuse link 3 but, if desired, restraining wire 8 may be arranged in such a fashion as to shunt but a portion of

fuse link 3. Since striker pin 12 is supposed to perform a significant amount of work incident to blowing of the fuse, spring 11 must be relatively strong, and this calls for a restraining wire 8 of steel having a relatively large diameter and, therefore, a relatively small resistance. Hence restraining wire 8 tends to shunt away a significant percentage of the current to be carried by ribbon fuse link 2, thus tending to change the current rating which the fuse structure had in the absence of restraining wire 8. Resistor 14 inserted into restraining wire 8 eliminates that tendency by greatly increasing the resistance of the shunt path formed by wire 8.

Because steel restraining wire 8 must have a relatively large cross-section, its presence tends to significantly increase the minimum fusing current of ribbon silver link 2, unless the resistance of restraining wire 8 is sufficiently increased by insertion into it of a resistor 14 having a relatively high ohmic value. While the latter should not be too high, it should be sufficiently high to maintain the minimum fusing current as determined by fuse link means 2 in the presence of all other elements of the fuse structure including filler 15, but in the absence of restraining wire 8.

The fuse structure of FIGS. 1 and 2 is intended for relatively high circuit voltages, i.e. voltages above 600 volts, say in the order of a few kilovolts. In such fuses the fuse link 2 is generally made of silver and the arc-quenching filler consists generally of quartz sand, this combination of link metal and filler material being conducive to the generation of relatively high arc voltages which are particularly appropriate where the circuit voltage is relatively high. In such fuses the filler is converted under the action of electric arcs into a glass-like substance, known as fulgurite, which is in the nature of a semiconductor and has a relatively low ohmic resistance as long as it is hot. A hot fulgurite has, therefore, a tendency to allow small currents to flow across a fuse after blowing thereof and successful interruption by the fuse of a faulted circuit. The fulgurite resulting from vaporization of striker pin restraining wires of steel are fulgurites which are particularly dangerous because they are formed at a relatively late point of time in the interrupting process, at which time the fulgurite resulting from vaporization of the current carrying fuse link has cooled to such an extent as to reduce the flow of follow-currents through such fulgurites below a danger level. The resistor 14 shown in FIGS. 1 and 2 is made of a material adapted not to fuse under the action of let-through currents through restraining wire 8 incident to blowing of the fuse structure. Therefore vaporization of restraining wire 8 will result in the formation of a fulgurite having a right section and having a left section, which sections are separated by a high resistance gap substantially coextensive with resistor 14. The presence of this gap either suppresses follow-currents, or reduces such currents to harmless magnitudes. Resistor 14 may be a carbon resistor. Such resistors may explode under the action of relatively high follow currents yet, by exploding, they operate as an effective circuit interrupter, establishing a gap whose dielectric strength is sufficiently high to inhibit the further flow of a follow current.

Upon occurrence of a major fault current fuse link 2 fuses at all points thereof of reduced cross-section formed by transverse lines of perforations, thus establishing a plurality of series breaks at the points of break exposed by windows 6 in plates 5 to the immediate action of the arc-quenching quartz filler 15. The arc voltage will be relatively high, but decay relatively rapidly, as characteristic of arc voltages of arcs burning in quartz sand. At the points of break shielded by plates 5 from the immediate action of the arc-quenching quartz filler 15 the arc voltage will be relatively small, but decay less rapidly than at the points of break where the arc-quenching quartz filler is allowed to act upon the arc. As a result of the summation of partial arc voltages having such different time-current characteristics an aggregate arc voltage is

obtained which is of a relatively stable nature, as preferred in high-interrupting capacity current-limiting fuses. The theory underlying the formation of such composite arc voltage is more fully set forth in United States Patent 2,964,604, to P. C. Jacobs, Jr., et al., December 13, 1960, Current-Limiting Fuses Having Compound Arc-Voltage Generating Means, and reference may be had to that patent for information of this particular aspect of the structure of FIG. 1 and 2. As a result of the arc voltage generated upon fusion of fuse link means 2, the fault current decays rapidly to zero. The increasing voltage across terminal caps 3 causes a flow of current through restraining wire 8, increasing in magnitude in proportion to the voltage across terminal caps 3. The magnitude of this current is limited by resistor 14, yet that current is sufficiently high to cause rapid fusion of wire 8. Hence electric arcs are kindled to both sides of resistor 14. Resistor 14 is made of a material that does not fuse under the action of the let-through current through wire 8 incident to blowing of the fuse. Resistor 14 may be a carbon resistor whose dimensions are selected in such a fashion that resistor 14 explodes under the action of the let-through currents which flow through it and through wire 8, incident to blowing of the fuse. If filler 15 is formed by quartz sand a fulgurite will form which is substantially coextensive with wire 8. This fulgurite will have a gap at the region of resistor 14 whose dielectric level remains always high, thus precluding the flow of leakage current of a dangerous magnitude. The formation of such a gap is due to the fact that no arcing occurs in the region of resistor 14. Resistor 14 may effectively resist burn-back of wire 8 beyond the end surfaces of resistor 14, or it may establish by its explosion a gap which has a high dielectric strength at the time of its formation.

Upon fusion of wire 8 spring 11 projects striker pin 12 from its left restrained position (shown in FIGS. 1 and 2) to its right operating position (not shown) thus tripping a circuit breaker or performing an equivalent amount of mechanical work.

In FIGS. 3–5 substantially the same reference characters as in FIGS. 1 and 2, however, with a prime added, have been applied to designate like parts. Thus 1′ is a tubular casing of insulating material closed on both ends by terminal caps 3′. Casing 1′ houses a wire supporting core 5′ which may be made of a ceramic material and has a central or axial bore 6′. Core 5′ supports a fusible conductor 2′ in wire-form having ends projecting through caps 3′ and conductively connected to caps 3′ by pools 4′ of solidified solder. A portion of the length of fusible conductor 2′ is arranged on the outer surface of core 5′, while another portion of the length of fusible conductor 2′ is threaded through passages 7′ provided in core 5′. Thus the design shown in FIGS. 3–5 complies with the teachings set forth in United States Patent 2,877,321 to Philip C. Jacobs, Jr., March 10, 1959, High Voltage Fuses, and reference may be had to that patent for additional information in regard to the advantages that may be obtained by applying a support for the fusible element 2′ of the type shown in FIGS. 3–5. In the particular arrangement shown in FIGS. 3–5 the fusible wire 2′ is zig-zaging between the ends of passages 7′ across core 5′, a total of seven such passages being provided at various levels of core 5′. Core 5′ and fusible conductor 2′ are submersed in the pulverulent arc-quenching filler 15′ which may be quartz sand. The latter fills also central bore 6′ in wire-supporting-core 5′. Steel restraining wire 8′ is arranged inside of bore 6′ in coaxial relation thereto and the right end thereof projects through an opening in outer cap 9′ and is secured to abutment member 13′. The latter forms an integral part of striker pin rod 16′ slidable in a perforation in cap 10′ and attached to striker pin 12′. The latter is arranged in the inner cap 10′ and under the bias of helical spring 11′ also arranged inside of inner cap 10′. Resistor 14′ is arranged inside

bore 6' and subdivides wire 8' in two separate sections.

The flow of excess currents results in fusion of wire link 2'. Following fusion of wire link 2' which is preferably made of silver the voltage across terminal caps 3' increases substantially, resulting in the increase of current flow through steel restraining wire 8'. This causes rapid fusion of the latter and formation of a fulgarite inside of bore 6', except along a portion of the length thereof occupied by, and adjacent to, resistor 14'. Upon fusion of wire 8' striker pin 12' is projected from its restrained position to the right, simultaneously performing a predetermined mechanical operation as, for instance, tripping a circuit breaker.

While, in accordance with the patent statutes, I have disclosed the details of two preferred embodiments of my invention, it is to be understood that many of these details are merely illustrative and variations in their precise form will be possible, or necessary, depending upon the particular nature of application.

I desire, therefore, that my invention be limited only to the extent set forth in the appended claims and by the prior art.

I claim as my invention:

1. An electric fuse comprising in combination:
a tubular casing of insulating material;
a pair of terminal elements closing the ends of said casing;
fuse link means conductively interconnecting said pair of terminal elements;
a striker pin having a restrained position and an unrestrained position arranged adjacent one of said pair of terminal elements;
means biasing said striker pin from said restrained position toward said unrestrained position thereof;
a fusible restraining conductor of steel arranged to form a shunt path at least across a portion of said fuse link means and normally restraining said striker pin in said restrained position thereof;
a pulverulent fulgarite-forming arc-quenching filler in said casing, said fuse link means and said restraining conductor being submersed in said filler; and
an additional non-metallic resistor included in said restraining conductor.

2. An electric fuse comprising in combination:
a tubular casing of insulating material;
a pair of terminal elements closing the ends of said casing;
fuse link means of a metal having a relatively high conductivity interconnecting said pair of terminal elements;
a striker pin having a restrained position and an unrestrained position arranged adjacent one of said pair of terminal elements;
spring means biasing said striker pin from said restrained position toward said unrestrained position thereof;
a restraining wire of steel conductively interconnecting said pair of terminal elements forming a shunt path across said link means and normally restraining said striker pin in said restrained position thereof;
a pulverulent fulgarite-forming arc-quenching filler in said casing, said fuse link means and said restraining wire being submersed in said filler; and
an additional resistor included in said restraining wire between the ends thereof adding lumped resistance to said shunt path, said resistor consisting of a non-metallic resistance material.

3. An electric fuse comprising in combination:
a tubular casing of insulating material;
a pair of terminal elements closing the ends of said casing;
a fuse link means of a metal having a relatively high conductivity conductively interconnecting said pair of terminal elements;

a striker pin having a restrained position and an unrestrained position arranged adjacent one of said pair of terminal elements;
a spring biasing said striker pin from said restrained position toward said unrestrained position thereof;
a fusible restraining wire of a metal having a relatively low conductivity arranged to form a shunt path at least across a portion of said fuse link means and normally restraining said striker pin in said restrained position thereof;
a pulverulent fulgarite-forming arc-quenching filler in said casing, said fuse link means and said restraining wire being submersed in said filler; and
means for increasing the resistance of said shunt path beyond the magnitude determined by the length and conductivity of said restraining wire, said resistance increasing means comprising a non-metallic resistor interposed in said restraining wire between the ends thereof.

4. An electric fuse comprising in combination:
a tubular casing of insulating material;
a pair of terminal elements closing the ends of said casing;
a fuse link means of silver conductively interconnecting said pair of terminal elements and predetermining the minimum fusing current of said fuse;
a striker pin having a restrained position and an unrestrained position arranged adjacent one of said pair of terminal elements;
spring means biasing said striker pin from said restrained position toward said unrestrained position thereof;
a fusible restraining conductor of steel arranged to form a shunt path at least across a portion of said fuse link means and normally restraining said striker pin in said restrained position thereof, said restraining conductor having a sufficiently large cross-section to shunt a sufficiently high current from said fuse link means to substantially increase said minimum fusing current of said fuse as predetermined by said fuse link means;
a silicious fulgurite-forming arc-quenching filler in said casing, said fuse link means and said restraining conductor being submersed in said filler; and
an additional non-metallic resistor included in said restraining conductor for limiting the current flow through said restraining conductor to the extent required for substantially maintaining said minimum fusing current of said fuse as predetermined by said fuse link means.

5. An electric fuse comprising in combination:
a tubular casing of insulating material;
a pair of terminal elements closing the ends of said casing;
fuse link means conductively interconnecting said pair of terminal elements;
a striker pin having a restrained position and an unrestrained position arranged adjacent one of said pair of terminal elements;
spring means biasing said striker pin from said restrained position toward said unrestrained position thereof;
a fusible restraining conductor arranged to form a shunt path across at least a portion of said fuse link means and normally restraining said striker pin in said restrained position thereof;
a pulverulent arc-quenching quartz filler inside said casing embedding said fuse link means and said restraining conductor therein; and
an additional non-metallic resistor included in said restraining conductor for increasing the resistance of said shunt path, said additional resistor being adapted not to fuse under the action of the let-through currents through said restraining conductor incident to blowing of the fuse.

6. An electric fuse comprising in combination:
a tubular casing of insulating material;
a pair of terminal elements closing the ends of said casing;
fuse link means conductively interconnecting said pair of terminal elements;
a striker pin having a restrained position and an unrestrained position arranged adjacent one of said pair of terminal elements;
spring means biasing said striker pin from said restrained position toward said unrestrained position thereof;
a fusible restraining conductor arranged to form a shunt path across at least a portion of said fuse link means and normally restraining said striker pin in said restrained position thereof;
a pulverulent fulgurite-forming arc-quenching filler in said casing, said fuse link means and said restraining conductor being submersed in said filler; and
a carbon resistor included in said restraining conductor for increasing the resistance of said shunt path.

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