

March 25, 1958

C. L. McALISTER

2,828,390

PROTECTORS FOR ELECTRIC CIRCUITS

Filed Sept. 24, 1953

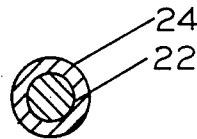
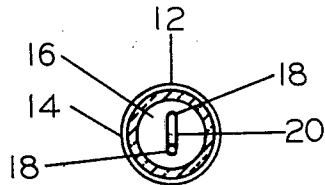
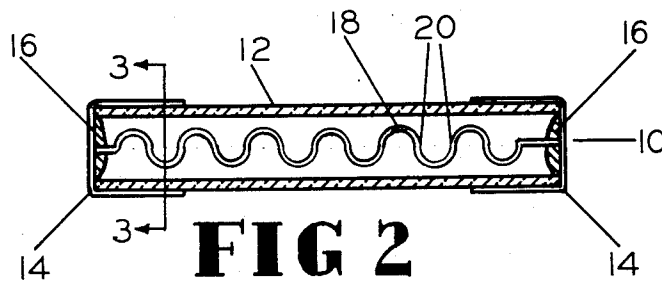
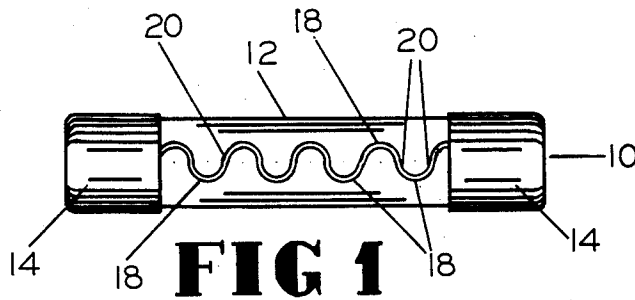
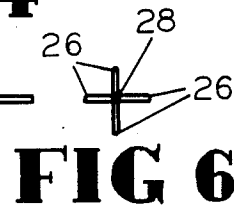
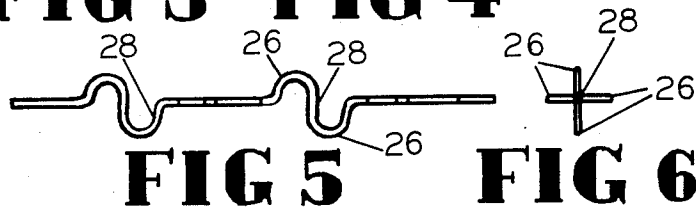


FIG 5 **FIG 6**



INVENTOR
Craig L. Mc Alister

BY *Ray Eilers*
ATTORNEY

1

2,828,390

PROTECTORS FOR ELECTRIC CIRCUITS

Craig L. McAlister, Overland, Mo., assignor to McGraw-Edison Company, a corporation of Delaware

Application September 24, 1953, Serial No. 382,023

19 Claims. (Cl. 200—131)

This invention relates to improvements in protectors for electric circuits. More particularly this invention relates to improvements in protectors for electric circuits which have light weight fusible elements.

It is therefore an object of the present invention to provide an improved protector for electric circuits which has a light weight fusible element.

In the manufacture of protectors for electric circuits, it is frequently the practice to enclose fusible elements in housings; the housings protecting the fusible elements from injury and also protecting adjacent objects from the arcing that can accompany the fusing of the fusible element. A great number of these protectors for electric circuits have cup-shaped terminals mounted on the ends of the housing, and in many such instances the fusible elements are connected to those terminals by solder. In a great number of instances the solder is in engagement with the inner surfaces of the terminals and that solder will then electrically connect the ends of the fusible elements to the inner surfaces of the terminals. The solder can be inserted in the housing, and the housing then is placed in engagement with the terminal, and thereafter the fusible element can be telescoped within the housing. Where this is done, it is usually possible to apply heat to the terminal to cause the solder to melt and flow around the end of the fusible element and into intimate engagement with the inner surface of the terminal. However, where the fusible element is light in weight, that fusible element can frequently be too light in weight to overcome the surface tension of the molten solder. In such instances, the fusible element will rest on the surface of the solder and will not form a good electrical bond with that solder and thus will not form a good electrical connection with the terminal of the protector for electric circuits. This, of course, is objectionable. The present invention obviates this objection by providing heavier than normal fusible elements for small protectors for electric circuits. Such fusible elements will be able to overcome the surface tension of the molten solder and thus to penetrate that molten solder and be intimately connected with the terminals of the protector for electric circuits. It is therefore an object of the present invention to provide heavier than usual fusible elements for small protectors for electric circuits.

Bends in the fusible element make it easy to see that element in a transparent housing and thus enables ready location of "blown" elements. This is a considerable improvement over straight-through fuses of small size that could be obscured by linear reflections from such a housing.

The present invention provides a heavier than usual fusible element for small protectors for electric circuits by selecting an elongated conductor which is considerably longer than the distance between the terminals on the housing, and by forming a plurality of bends intermediate the ends of that conductor. The greatly increased length of the fusible element will proportionately increase the weight of the element and will enable that element to overcome the surface tension of the molten solder and to

2

penetrate that solder. The fusible element will be able, because of the bends intermediate its length, to have portions thereof radiating heat toward other portions thereof. In addition, that fusible element will have a length that is greater than the length of fusible elements normally used in such small protectors for electric circuits; and thus it will have a greater resistance and greater heat generating capacity. The combined effect of the greater resistance of the fusible element and the fact that portions of the fusible element can radiate heat toward other portions of that element, enables that element to be made larger in cross section as well as longer in length and still have the same rating as the usual fusible element for those small protectors. The increased cross section co-acts with the increased length of the fusible element to make the increase in the weight of the fusible element quite sizable. As a result, the weight of the fusible element is adequate to overcome the surface tension of the solder. It is therefore an object of the present invention to provide a fusible element, for a protector for electric circuits, which is made longer than the distance between the terminals of that protector and which is made of greater cross section than the fusible elements of the same rating that are normally used in the said protector.

The ends of the fusible element provided by the present invention are coated with a sheath of silver. Silver alloys with solder more readily than do most metals, and therefore the provision of the silver sheaths on the fusible element facilitates the penetration of the solder. This penetration is a combined result of an alloying action and the greater ability of the silver to be "wet" by molten solder. It is therefore an object of the present invention to provide silver sheaths on the ends of fusible elements that are to be secured to the terminals of protectors for electric circuits by solder.

The fusible element provided by the present invention can be further increased in weight by forming that fusible element of a cupreous conductor that is encased in a sheath of silver. When a thin coating of silver is applied to a cupreous conductor, the thin coating of silver co-acts with the exterior surface of the cupreous conductor to provide an overall reduction in the current-carrying ability of that conductor. Thus, a copper wire of a given diameter will carry less current after it has received a thin coating of silver than it carried before; and this despite the fact that the silver increased the overall cross section of the wire and that silver is a better conductor of electricity than is copper. The resultant reduction in the current-carrying ability of the copper wire appears to stem from an alloying action between the exterior surface of the copper wire and the interior surface of the silver coating. The present invention utilizes this reduction in the current-carrying ability of cupreous conductors to initially reduce the current-carrying ability of those conductors and then increases the thickness of the silver coating to raise the current-carrying ability of the sheathed conductor to a value equal to or above the current-carrying ability of the bare cupreous conductor. In this way, the present invention is able to increase the cross section and thus the weight of the fusible element without a corresponding increase in the current-carrying ability of that conductor. It is therefore an object of the present invention to provide a fusible element which consists of a cupreous conductor with a sheath of silver thereon.

The silver atoms in the silver sheath will tend to migrate into the cupreous conductor, and the copper atoms of that conductor will tend to migrate into the silver sheath; and these migrations will become quite pronounced at elevated temperatures. At such temperatures the silver atoms of the sheath will absorb oxygen from the air and will transmit that oxygen to the copper atoms of the cupreous conductor; thereby fostering the

3

formation of copper oxide. The migration of the silver and copper atoms and the formation of copper oxide will be negligible at room temperatures, but will be accelerated when the fusible element is heated, as by long-continued heavy overloads. Consequently, the resistance of the element will be low until heavy overloads occur and cause the copper oxide to form. That oxide of copper will have a much greater resistance to electric current than does the copper itself; and thus the resistance of the fusible element will increase. This increased resistance will increase the heating action of the fusible element; and if the overload continues too long the heating action will be sufficient to fuse or "blow" the fusible element, and thereby protect the circuit from injury. It is therefore an object of the present invention to provide a fusible element which is a cupreous conductor encased in a sheath of silver.

Protectors for electric circuits that have fusible elements of small cross section frequently experience a sagging of the fusible element into engagement with the interior surface of the housings for those protectors. The engagement between the fusible elements and those housings is due to an elongation of the fusible elements through the thermal expansion of those elements; and it is this thermal expansion that leads to the sagging which permits those fusible elements to engage those housings. The engagement between the fusible elements and the interior surfaces of the housings is objectionable since it can enable the housings to absorb varying amounts of heat from those fusible elements and can vary the ratings of the protectors for electric circuits. Where the areas of engagement between the fusible elements and the interior surfaces of the housings are large, the change in rating can be quite serious. In addition, where the housings are made of fibre, a usual material for the housings of protectors for electric circuits, the engagement between the fusible elements and the interior surfaces of the housings can create a fire hazard. The present invention obviates any such fire hazard, and it also obviates appreciable variations in the ratings of protectors for electric circuits by making the housings for those protectors of heat resistant material and by forming the fusible elements with portions of limited area that can engage the interior surfaces of those housings and hold the remaining portions of the fusible elements out of engagement with those interior surfaces. These other portions will be fusible on overloads, and thus they will be able to "blow" in the presence of overloads, and yet they will be substantially isolated from the heat-absorbing effects of the interior surfaces of the housings by the portions of the fusible elements which do engage those interior surfaces. Consequently, any sagging of the fusible elements will not appreciably affect the ratings of the protectors for electric circuits and will not create a fire hazard. It is therefore an object of the present invention to provide a protector for electric circuits which has a heat-resistant housing and which has a fusible element with portions of limited area than can engage the interior surface of that housing to hold the remaining portions of that fusible element out of engagement with the interior surface of the housing.

Other and further objects and advantages of the present invention should become apparent from an examination of the drawing and accompanying description.

In the drawing and accompanying description several preferred embodiments of the present invention have been shown and described but it is to be understood that the drawing and accompanying description are for the purpose of illustration only and do not limit the invention and that the invention will be defined by the appended claims.

In the drawing,

Fig. 1 is a front elevational view of a protector for electric circuits that is made in accordance with the principles and teachings of the present invention,

4

Fig. 2 is a longitudinal sectional view taken along the center of the protector for electric circuits of Fig. 1,

Fig. 3 is a cross sectional view of the protector of Figs. 1 and 2 and it is taken along the plane indicated by the line 3—3 in Fig. 2,

Fig. 4 is a greatly enlarged cross sectional view of the fusible elements of Figs. 1—3,

Fig. 5 is a front elevational view of another form of fusible element provided by the present invention,

Fig. 6 is an end elevational view of the fusible element of Fig. 5,

Fig. 7 is a front elevational view of another form of fusible element provided by the present invention, and

Fig. 8 is an end elevational view of the fusible element of Fig. 7.

Referring to the drawing in detail, the numeral 10 generally denotes a protector for electric circuits. The protector 10 has a housing 12 of heat resistant material, and that housing is in the form of a cylinder. The housing 12 is preferably made of glass or glass fibres impregnated with melamine. Such materials are free from the charring that fibre is subject to when engaged by a heated fusible element. The opposite ends of the housing 12 are provided with terminals 14. These terminals are cup-shaped and the terminals telescope over the ends of the housing 12. Solder 16 is secured to the inner faces of the terminals 14 and the solder is connected to the ends of the fusible element of the protector 10. This fusible element is an elongated conductor that is bent intermediate its ends to provide portions 18 that are closer to the interior surface of the housing 12 than are other portions 20. Current will flow from one of the terminals 14 through one mass of solder 16 through the fusible element to the mass of solder at the other end of the protector 10, through the solder at the other end of the protector 10 and then through the other terminal 14. The fusible element will be able to carry a predetermined amount of current indefinitely but will fuse or "blow" on overloads that are greater than the normal amount of current by a predetermined percent. Thus, the protector for electric circuits will carry the current needed in the circuit but will "blow" before that current attains dangerous proportions.

In assembling the protector 10, the solder 16 is placed in the terminals 14 and those terminals are heated to cause the solder 16 to melt and flow. At such time the terminals 14 are set with their bottoms down and with the side walls thereof extending upwardly to confine and hold the molten solder. The housing 12 is then set in a vertical position and one end thereof is telescoped downwardly into one of the terminals 14. The fusible element is then dropped into the upper end of the housing 12. The lower end of the fusible element will pass downwardly through the housing 12 and will strike and penetrate the molten solder 16. Thereafter, the terminal 14 and the solder 16 therein are permitted to cool; thus uniting the housing 12, the fusible element and the one terminal and the one mass of solder together as a unit. Thereupon, the unit is inverted and the open end of the housing 12 is placed within the other heated terminal 14. The solder 16 in that terminal will be molten and will receive and surround the other end of the fusible element. Thereafter, the heated terminal 14 and the molten mass of solder therein will be permitted to cool and complete the assembly of the protector 10.

In some instances, the protector 10 will be quite small, both physically and electrically. For example, in some instances, the overall physical length of the protector will be less than an inch and a half, and the rated current of the protector 10 will be one ampere. A fusible element that is capable of "blowing" on loads of an ampere and a quarter, and that will fit into such a small protector will be too light in weight to overcome the surface tension of the molten solder. As a result, when such a fusible element would be dropped in the housing

5

12, it would fall to the bottom of the housing and rest upon the molten solder. This, of course, is objectionable since it would preclude a good electrical connection between the end of the fusible link and the terminal 14. The fusible element provided by the present invention is enabled to overcome the surface tension of the molten solder and to penetrate that solder by being made longer than the distance between the terminals 14 and by having a number of bends intermediate the ends thereof. The increased length of the fusible element increases the heating effect of that element over a straight-through fusible element of the length of the housing 12, and the bends in the fusible element enable parts of that fusible element to radiate heat toward other parts of that fusible element. The increased heating of the bent fusible element will coat with the radiating effect of the parts of that element and the small space in which the long fusible element is confined to lower the rating of that fusible element. The rating of that fusible element can be increased by increasing the cross section of that fusible element, and this is done. The increased cross sectional area of the fusible element will coat with the increased length of that fusible element to make that element heavy enough to overcome the surface tension of the solder and to penetrate that solder. In addition, the increased cross section of that fusible element will increase the stiffness of that fusible element; and that increased stiffness is important when the housing 12 is inverted and telescoped into the other terminal 14. If, at that time, the fusible element is not sufficiently stiff, it could bend somewhat rather than penetrate the molten solder in that other terminal 14. However, by bending the fusible element the present invention is able to increase the cross sectional area of that fusible element to the point where that element is stiff enough to overcome the surface tension of the molten solder. Consequently the fusible element can be dropped in the housing 12 and will penetrate the one mass of solder and will have sufficient stiffness that it will penetrate the other mass of solder when the housing 12 is inverted and telescoped into the other terminal 14.

When long continued overloads must be carried by the protector 10, the fusible element of that protector will become quite hot. As that element becomes hot, it will tend to elongate due to the thermal coefficient of expansion of the metal of that fusible element. Where the overloads are high and are long continued, the elongation of the fusible element may be great enough to cause that fusible element to bow toward the inner surfaces of the housing 12. In fact, in some cases, the fusible element can actually bow into contact with the inner surfaces of the housing 12. Such contact will not char the inner surfaces of that housing because that housing is heat resistant. That contact will tend to enable the housing 12 to absorb heat from the portions of the fusible element that are in contact with the housing 12, but that heat absorption will not upset the rating of the protector 10 because other portions 20 of the fusible element are held out of contact with the inner surface of the housing 12 by the contacting portions 18. The portions 20 of the fusible element will be fusible and those portions will be able to "blow" when the overload in the circuit reaches too high a value. In this way, the bends in the fusible element of the protector 10 keep the rating of that protector constant. The fusible element of the protector 10 is bent so all of the portions thereof lie in the same plane. Moreover, the fusible element of the protector 10 will respond to elongation to move the portions 18 toward the inner surface of the housing 12 while still maintaining all the portions 18 and 20 in that same plane. This avoids a bowing of the fusible element that might place some of the portions 20 thereof in engagement with the inner surface of the housing 12.

The fusible element of the protector 10 will preferably be made as a cupreous conductor 22 that is encased in a

6

sheath 24 of silver. The cupreous conductor 22 may be of copper, of brass, of bronze or of other copper-containing alloys. The sheath 24 of silver may be formed on the cupreous conductor 22 in a number of ways, but electroplating is preferred. Electroplating provides a very intimate atom to atom engagement between the silver and the copper of the sheath and cupreous conductor respectively and it provides a sheath of uniform thickness. During the electroplating of the cupreous conductor 22, there is an initial reduction in the current-carrying ability of that conductor. Thus, if a thin coating of silver were to be plated onto a cupreous conductor to protect that conductor from corrosion, the overall current-carrying ability of the composite fusible element would be less than the current-carrying ability of the bare cupreous conductor; and this despite the fact that the overall cross section of the fusible element is greater than that of the cupreous conductor, and despite the fact that silver is a better conductor of electricity than is the cupreous conductor. Accordingly, it is necessary that a thicker sheath of silver 24 be provided than is customarily provided to protect copper from corrosion. The sheath 24 of silver should preferably be thick enough so the cross sectional area of the sheath is at least one fifth of the cross sectional area of the bare cupreous conductor. Where this is done, the current-carrying ability of the fusible element is equal to or greater than the current-carrying ability of the bare cupreous conductor. The sheath 24 of silver will increase the weight of the fusible element and will help that fusible element overcome the surface tension of the solder during the assembly of the protector 10.

Under normal conditions of load, the fusible element of the protector 10 will carry current without undue heating. However, on overloads, the fusible element will generate considerable heat and this heat will cause the silver of the sheath 24 to transmit the oxygen of the air surrounding the fusible element to the cupreous conductor 22 of that element. At very high temperatures, induced by heavy overloads, the transmission of oxygen to the cupreous conductor 22 is appreciable and is rapid. This oxygen will combine with the copper of the cupreous conductor to form an oxide of copper, and that oxide will have a greater resistance to the flow of current than does the copper of the conductor 22. This increased resistance will further increase the heating of the fusible element and if the overloads are continued long enough or if they are heavy enough, the fusible element will fuse or "blow." This will protect the circuit against dangerous overload.

The thickness of the sheath 24 will vary somewhat with the size of the cupreous conductor 22, but a preferred thickness of silver is in the range of two ten thousandths (0.0002) of an inch to one thousandth (0.001) of an inch. Thicknesses in excess of this preferred range can be used, but the advantages are very likely to be outweighed by the high cost of the silver; and the preferred range has been found to provide the required thicknesses. Thus, for a number forty three copper wire, a silver sheath that is two ten thousandths (0.0002) of an inch in thickness has been very successful. The bi-metallic fusible element formed in this way has a rating of one and a half amperes. A number thirty four copper wire has been coated with a sheath of silver that is eighty five one hundred thousandths (0.00085) of an inch thick; and that fusible element has had a rating of five amperes. The sheath of silver 24 is useful in increasing the weight of the fusible element of the protector 10, but it is also advantageous in larger fuses which do not require the extra weight to overcome the surface tension of solder. The action of the silver in transmitting oxygen to the copper at high temperatures provides a prompt opening of the circuit when dangerous overloads are being created, and yet enables the fusible elements to operate continuously at their rated loads.

The lateral distance between the portions 18 of the

fusible element of the protector 10 will preferably be less than the internal diameter of the housing 12. However, it may, in some cases, be desirable to make the lateral distances between the portions 18 of the fusible element protector 10 as large as the internal diameter of the housing 12. Where this is done, the portions 18 will continuously contact the inner surface of the housing 12 and will continuously hold the portions 20 of that fusible element out of contact with the inner surface of the housing 12.

Fig. 5 shows another form of fusible element provided by the present invention. This fusible element has portions 26 that are closer to the inner surface of the housing with which the fusible element is used than are other portions 28 of that fusible element. The portions 26 will hold the portions 28 out of engagement with the inner surface of the housing in which the fusible element is disposed, irrespective of the manner in which the fusible element bows. This is possible because the portions 26 of the fusible element lie in different planes and no matter how the fusible element bows, one or more of the portions 26 will engage the inner surface of that housing and hold the portions 28 out of contact with that inner surface. If desired, of course, the lateral spacing between the portions 26 of the fusible element could be as large as the inner diameter of the housing; and in that case the bowing would be largely restricted.

Fig. 7 discloses a helical fusible element 30. This fusible element, as will the fusible element of Figs. 5 and 6, preferably be made as a sheathed cupreous conductor. The sheath will be of silver and will increase the weight of the fusible element and will also provide oxygen transmission at high temperatures. The diameter of the helical fusible element 30 will preferably be less than the internal diameter of the housing with which that fusible element will be used. Where that is the case, the helical fusible element 30 will have an air gap between it and the inner surface of the housing therefor. If the helical fusible element 30 tends to bow or elongate on overload, some portions of that fusible element will be closer to the inner surface of the housing than will other portions. If the elongation or bowing is excessive, one or more of the first said portions will contact the inner surface of the housing and will hold the other portions out of contact with that housing. Here again, the bending of the fusible element intermediate its ends will enable that fusible element to maintain its rating even though portions thereof contact the inner surface of the housing therefor.

The fusible elements provided by the present invention will be sheathed in silver before they are bent. The sheathing of the conductors provided by the present invention and the subsequent bending of those conductors enables an interaction to occur between the atoms of the conductor and the atoms of the sheath. This interaction serves as a work hardening of the fusible element and makes it quite stiff. The stiffness is valuable where the assembled housing and fusible element are thrust into a terminal with molten solder in the bottom thereof.

The bending of the fusible elements intermediate their ends makes it possible to use fusible elements that are longer and of heavier cross section than straight-through fusible elements of the same rating. The provision of silver-sheathed fusible elements enables fusible elements of greater cross section and weight to be used. Consequently, the fusible elements provided by the present invention have enough weight to overcome the surface tension of solder and thus penetrate that solder. In some cases the silver sheaths for the cupreous conductors will be heavy enough to enable unbent fusible elements to overcome the surface tension of the solder. Moreover, the reaction to overloads of the fusible elements provided by the present invention, is so favorable that those fusible elements can be used where the surface tension of the solder does not constitute a problem.

Whereas the drawing and accompanying description have shown several preferred embodiments of the present invention, it should be apparent to those skilled in the art that various changes may be made in the form of the invention without affecting the scope thereof.

What I claim is:

1. A protector for electric circuits that comprises a housing, terminals on said housing, a fusible element disposed within said housing, and solder that electrically connects the ends of said fusible element to said terminals, said fusible element being a cupreous conductor that is encased in a silver sheath, said sheath of silver responding to high temperatures induced by overloads to transmit oxygen to said cupreous conductor to form copper oxide, the transmission of oxygen to said cupreous conductor by said sheath of silver forming sufficient copper oxide on continued overloads to cause said fusible element to "blow."

2. A protector for electric circuits that comprises a housing, terminals on said housing, a fusible element disposed within said housing, and solder that electrically connects the ends of said fusible element to said terminals, said fusible element being a cupreous conductor that is encased in a silver sheath, said sheath of silver responding to high temperatures induced by overloads to transmit oxygen to said cupreous conductor to form copper oxide, the transmission of oxygen to said cupreous conductor by said sheath of silver forming sufficient copper oxide on continued overloads to cause said fusible element to "blow," the cross-sectional area of said sheath of silver being at least one-fifth the cross sectional area of said cupreous conductor.

3. A fusible element, for a protector for electric circuits, that comprises an elongated metallic conductor, said conductor having silver-encased ends, said conductor having a plurality of bends throughout the major portion of the length thereof, said bends defining portions of said conductor that can radiate heat toward other portions of said conductor and also providing said conductor with a developable length that is greater than a straight-line distance between said silver-encased ends, said silver-encased ends being adapted to coact with molten solder to "wet" said ends and thereby assure full and intimate bonding of said conductor and said solder, the weight of said elongated and bent conductor coacting with the "wetting" action induced by said silver-encased ends to facilitate gravity-induced penetration of molten solder by said silver-encased ends of said conductor.

4. A fusible element, for a protector for electric circuits, that comprises an elongated metallic conductor, said conductor being cupreous and being encased in a sheath of silver, said conductor having a plurality of bends throughout the major portion of the length thereof, said bends providing said conductor with a developable length that is greater than a straight-line distance between the ends thereof, said silver sheath being adapted to coact with molten solder to "wet" said ends and thereby assure full and intimate bonding of said conductor and said solder, the weight of said elongated and bent conductor coacting with the "wetting" action induced by said silver sheath to facilitate gravity-induced penetration of molten solder by said ends of said conductor.

5. A fusible element, for a protector for electric circuits, that fuses at temperatures of the order of the melting point of copper and that comprises an elongated conductor that has ends which can be secured to the terminals of said protector for electric circuits by solder, said conductor being cupreous and being encased in a sheath of silver, said conductor being larger and heavier than a cupreous conductor of the same current-carrying capacity and can thereby overcome the surface tension of molten solder.

6. A fusible element as claimed in claim 5 wherein the cross sectional area of said sheath of silver is greater

than one-fifth of the cross sectional area of said cupreous conductor.

7. A protector for electric circuits that comprises a housing of heat-resistant material, terminals on said housing, an elongated fusible element disposed within said housing, and solder that electrically connects the ends of said fusible element to said terminals, said ends of said fusible element defining a longitudinally-extending axis, said fusible element having a plurality of bends intermediate said ends thereof to define a plurality of portions that are spaced laterally from said axis, the lateral spacing between said axis and one of said laterally spaced portions of said fusible element enabling said one portion of said fusible element to be closer to the interior surface of said housing than is said axis, said one portion of said fusible element being spaced laterally from other of said laterally spaced portions of said fusible element, said lateral spacing between said one portion and said other portions of said fusible element enabling said one portion of said fusible element to hold said other portions of said fusible element out of contact with said interior surface of said housing in case said one portion of said fusible element should contact said interior surface of said housing.

8. A protector for electric circuits as claimed in claim 7 wherein said fusible element is an elongated conductor that is bent to form a series of contiguous arcs of reverse curvature.

9. A protector for electric circuits as claimed in claim 7 wherein said fusible element is an elongated conductor that is bent to form a series of alternately reversed re-entrant portions.

10. A protector for electric circuits as claimed in claim 7 wherein said fusible element is an elongated conductor that is bent to form a series of contiguous reentrant portions that lie in angularly spaced planes.

11. A protector for electric circuits as claimed in claim 7 wherein said fusible element is an elongated conductor that is bent to form a helix.

12. A protector for electric circuits as claimed in claim 7 wherein said fusible element is an elongated conductor that is bent to extend both circumferentially and axially of said housing.

13. In a fusible element for protectors for electric circuits, an elongated cupreous conductor, an intimately and closely adherent sheath of silver encasing said cupreous conductor, and a plurality of bends in said silver sheath and in said cupreous conductor, said silver sheath and said cupreous conductor being hardest adjacent said bends and rendering said fusible element resistant to bending.

14. The method of making a protector for electric circuits that comprises forming an elongated fusible element so it can fit within the housing of said protector for electric circuits without engaging the interior of said housing, placing solder in one of the cup-shaped terminals of said protector, heating said terminal to melt said solder, inserting one end of said housing of said protector in said terminal and in said solder, inserting said elongated fusible element in said housing whereby one end of said fusible element can engage and can respond to gravitational force to penetrate said molten solder, permitting said solder to cool and hold said fusible element and said terminal in physical and electrical engagement, placing solder in the other cup-shaped terminal of said protector, heating said other terminal to melt the solder therein, inserting the other end of said housing in said other terminal and the solder therein whereby the other end of said fusible element can engage and penetrate the molten solder in said other terminal, and permitting said other terminal and the solder therein to cool and hold said other end of said fusible element in physical and electrical engagement with said other terminal, said fusible element being a stiffened, elongated wire-like conductor that has a multiplicity of bends intermediate said ends thereof to increase its overall length and weight

whereby said fusible element can overcome the surface tension of the molten solder in the first said terminal.

15. The method of making a protector for electric circuits that comprises forming an elongated fusible element so it can fit within the housing of said protector for electric circuits without engaging the interior of said housing, placing solder in one of the cup-shaped terminals of said protector, heating said terminal to melt said solder, inserting one end of said housing of said protector in said terminal and in said solder, inserting said elongated fusible element in said housing whereby one end of said fusible element can engage and can respond to gravitational force to penetrate said molten solder by the weight of said fusible element, permitting said solder to cool and hold said fusible element and said terminal in physical and electrical engagement, placing solder in the other cup-shaped terminal of said protector, heating said other terminal to melt the solder therein, inserting the other end of said housing in said other terminal and the solder therein whereby the other end of said fusible element can engage and penetrate the molten solder in said other terminal, and permitting said other terminal and the solder therein to cool and hold said other end of said fusible element in physical and electrical engagement with said other terminal, said fusible element being a cupreous conductor that is in a sheath of silver.

16. The method of making a protector for electric circuits that comprises forming an elongated fusible element so it can fit within the housing of said protector for electric circuits without engaging the interior of said housing, placing solder in one of the cup-shaped terminals of said protector, heating said terminal to melt said solder, inserting one end of said housing of said protector in said terminal and in said solder, inserting said elongated fusible element in said housing whereby one end of said fusible element can engage and penetrate said molten solder, permitting said solder to cool and hold said fusible element and said terminal in physical and electrical engagement, placing solder in the other cup-shaped terminal of said protector, heating said other terminal to melt the solder therein, inserting the other end of said housing in said other terminal and the solder therein whereby the other end of said fusible element can engage and penetrate the molten solder in said other terminal, and permitting said other terminal and the solder therein to cool and hold said other end of said fusible element in physical and electrical engagement with said other terminal, said fusible element being a cupreous conductor that has been encased in a sheath of silver and that has been bent to form a plurality of bends intermediate its ends and to work harden it.

17. A protector for electric circuits that comprises electrically conductive terminals, a fusible element that is a cupreous conductor encased throughout the major portion of its length by a sheath of silver and solder that electrically connects the ends of said fusible element to said terminals, said sheath of silver normally isolating said major portion of the length of said cupreous conductor from the atmosphere surrounding said fusible element but responding to high temperatures induced by overloads to transmit oxygen to said cupreous conductor to form copper oxide, the transmission of oxygen to said cupreous conductor by said sheath of silver forming sufficient copper oxide on continued overloads to cause said fusible element to "blow."

18. A protector for electric circuits that comprises a housing of heat resistant material, terminals on said housing, a stiffened, elongated wire-like fusible element disposed within said housing, and solder that electrically connects the ends of said fusible element to said terminals, said housing being free of filler whereby said fusible element may come into engagement with the interior surface of said housing, said fusible element having a plurality of bends intermediate the ends thereof to define portions of said fusible element that are closer to the

11

interior surface of said housing than other portions of said fusible element, at least one of said other portions being fusible on overloads, said other portions of said fusible element being normally held out of engagement with the interior surface of said housing by the stiffness of said fusible element but being held out of engagement with said interior surface of said housing by the first said portions of said fusible element whenever said fusible element engages said interior surface of said housing, as upon excessive elongation of said fusible element on long continued overloads, said fusible element being a cupreous conductor encased in a silver sheath, the cross-sectional area of said silver sheath being greater than one-fifth the cross-sectional area of said cupreous conductor.

19. A protector for electric circuits that comprises a housing of heat resistant material, terminals on said housing, a stiffened, elongated wire-like fusible element disposed with said housing, and solder that electrically connects the ends of said fusible element to said terminals, said housing being free of filler whereby said fusible element may come into engagement with the interior surface of said housing, said fusible element having a plurality of bends intermediate the ends thereof to define portions of said fusible element that are closer to the interior surface of said housing than other portions of said fusible element, at least one of said other portions being fusible on overloads, said other portions of said fusible element being normally held out of engagement with the interior surface of said housing by the stiffness of said fusible element but being held out of engagement with said interior surface of said housing by the first said portions of said fusible element whenever said fusible

12

element engages said interior surface of said housing, as upon excessive elongation of said fusible element on long continued overloads, said fusible element being a cupreous conductor encased in a sheath of silver, the current carrying capacity of said fusible element being greater than the current carrying capacity of said cupreous conductor before it was encased in said sheath of silver, said sheath of silver transmitting oxygen to said cupreous conductor at high temperatures induced by overloads.

References Cited in the file of this patent

UNITED STATES PATENTS

964,592	Weston	July 19, 1910
988,873	Grohowsky	Apr. 4, 1911
1,208,448	Arthur	Dec. 12, 1916
1,703,940	Kollmar	Mar. 5, 1929
1,861,369	Sundt	May 31, 1932
2,148,803	Bussman	Feb. 28, 1939
2,157,906	Lohausen	May 9, 1939
2,313,373	Sundt	Mar. 9, 1943
2,337,938	Serfling et al.	Dec. 28, 1943
2,653,203	Kozacka	Sept. 22, 1953
2,659,790	Jurgensen	Nov. 17, 1953
2,682,587	Burt et al.	June 29, 1954

FOREIGN PATENTS

300,160	Great Britain	Oct. 29, 1928
484,782	Great Britain	May 10, 1938
541,116	Great Britain	Nov. 13, 1941
586,586	Great Britain	Mar. 24, 1947
592,733	Great Britain	Sept. 26, 1947