Aug. 16, 1966 T. E. L. FITZ GERALD 3,267,240

PROTECTORS FOR ELECTRIC CIRCUITS

Filed July 22, 1963

FIG. 2.

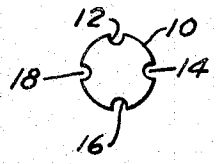


FIG. 1.

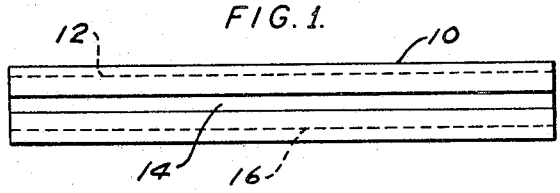


FIG. 4.

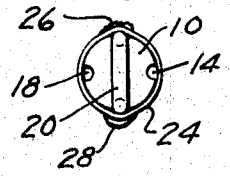


FIG. 3.

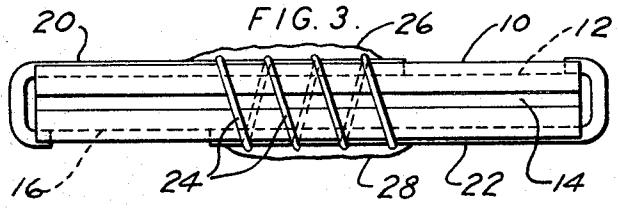


FIG. 6.

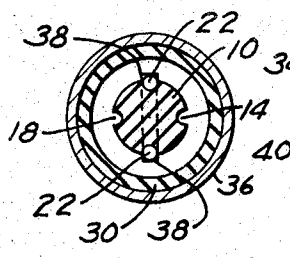


FIG. 5.

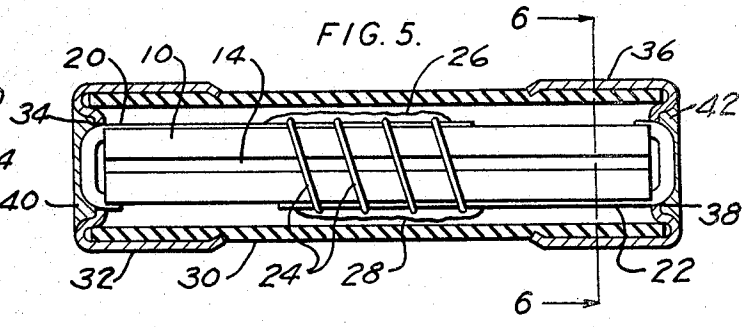


FIG. 7.

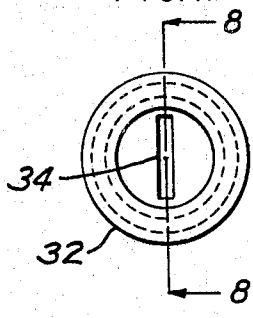


FIG. 8.

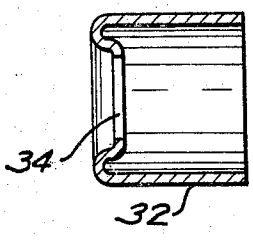
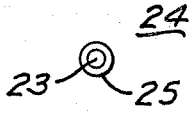


FIG. 9.



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3,267,240

PROTECTORS FOR ELECTRIC CIRCUITS

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Filed July 22, 1963, Ser. No. 296,611
5 Claims. (Cl. 200—131)

This invention relates to improvements in protectors for electric circuits. More particularly, this invention relates to improvements in electric fuses.

It is, therefore, an object of the present invention to provide an improved electric fuse.

Some electric devices are quite sensitive to voltage surges and to current surges. To adequately protect an electric device of that type, an electric fuse must, in response to a potentially hurtful current overload, promptly interrupt the circuit for that device in such a way that a hurtful voltage surge or a hurtful current surge can not develop. It would be desirable to provide an electric fuse that could respond to a potentially hurtful current overload to promptly open the circuit without permitting a hurtful voltage surge or a hurtful current surge to develop. The present invention provides such an electric fuse; and it is, therefore, an object of the present invention to provide an electric fuse which can respond to a potentially hurtful current overload to promptly open the circuit in such a way that a hurtful voltage surge or a hurtful current surge can not develop.

The electric fuse provided by the present invention uses a bimetallic fusible element; and one part of that fusible element has higher resistance and a higher melting point than does another part of that fusible element. The one part of that fusible element is preferably made as a central core, and the other part of that fusible element is preferably made as a coating for that core. The combined cross sections of the said one part and the said other part of that fusible element will be large enough to make the resistance of that fusible element small enough to enable that fusible element to carry the rated current of the fuse continuously without raising the temperature of the said other part of that fusible element to the melting point of that other part. However, the combined cross sections of the said one part and the said other part of that fusible element will be small enough to make the resistance of that fusible element large enough to enable that fusible element to respond to a potentially hurtful current overload to raise the temperature of the said other part of that fusible element to the melting point of that other part. As that other part of that fusible element reaches its melting point and starts to melt, its resistance will increase; and the resulting increase in the overall resistance of the fusible element will tend to keep a hurtful current surge from developing. As portions of the said other part of that fusible element fully melt, they will flow or draw away from the portions of the said one part of the fusible element which they initially encased; and, thereupon, the overall resistance of the fusible element will again increase. That further increase in the overall resistance of that fusible element will additionally tend to keep a hurtful current surge from developing. The said portions of the said one part of the fusible element will then melt; and as those portions melt their resistance will increase and will thus tend to keep a hurtful current surge from developing. The overall result is that the electric fuse provided by the present invention can respond to a potentially hurtful current overload to open the circuit while keeping a hurtful current surge from developing. It is, therefore, an object of the present invention to provide an electric fuse wherein the fusible element is bi-metallic, and one part of that fusible element has a higher resistance and a higher melting point than does another part of that fusible element.

As the fusible element of the electric fuse provided by the present invention fuses to open the circuit, it will experience the step-by-step increase in resistance described hereinbefore. However, once that fusible element starts to fuse, it will rapidly open the circuit. This is due to the fact that the said one part of that fusible element normally carries only a small part of the overall current and is wholly incapable of carrying an overload current. As a result, when the said other part of the fusible element fuses in response to a potentially hurtful current overload, the said one part of that fusible element will respond to its subjection to that overload to promptly fuse.

The said one part, of the fusible element of the electric fuse provided by the present invention, is preferably made from a metal which has a very high melting temperature and which has an even higher vaporizing temperature. Specifically, that one part is preferably made from a metal which has a melting temperature and a vaporizing temperature that are, respectively, considerably higher than the melting temperature and the vaporizing temperature of platinum. Where that one part is made from such metal, the vapors which are generated as that one part fuses will be at, or close to, the thermal ionization temperature of those vapors; and those vapors will promptly establish an arc. That arc will provide such a low resistance path through the fuse that a sharp rise in the voltage across that fuse cannot occur. This action is in contrast to the circuit-opening action of most fuses, wherein the temperatures of the vapors of the fusible elements are initially well below the thermal ionization temperatures of those vapors and wherein the voltage across the fuse must increase until those vapors can be ionized sufficiently to enable arcs to form. The voltage increases across those fuses are usually rapid and substantial; and those voltage increases produce voltage surges which could injure some electric devices. The present invention obviates all such voltage increases by incorporating into the fusible element of the fuse thereof a metal which has a vaporizing temperature at, or close to, the thermal ionization temperature of that metal.

An electric fuse with a fusible element consisting of a metal that had a vaporizing temperature at, or close to, the thermal ionization temperature of that metal would be desirable because it would promptly establish an arc when it fused. However, such a fuse would be undesirable because the fusible element thereof would have an unduly high resistivity. The present invention attains the benefits of a fusible element made from a metal which has a vaporizing temperature at, or close to, the thermal ionization temperature of that metal and yet avoids an unduly high resistivity for the fusible element of the fuse thereof by providing a bi-metallic fusible element for that fuse. The said one part of that fusible element will be the last to fuse, and the fusing temperature of the metal thereof will be so close to the thermal ionization of that metal that the said one part will facilitate prompt arc formation, and will thus obviate a potentially hurtful voltage surge. The metal of the other part of that fusible element will have a resistivity which is smaller than the resistivity of the metal of the said one part of that fusible element; and hence that other part of the fusible element will reduce the overall resistivity of the fusible element to a practical value. It is, therefore, an object of the present invention to provide an electric fuse which has a bi-metallic fusible element with one part thereof made from a metal that has a vaporizing temperature at, or close to, the thermal ionization temperature of that metal

and with another part thereof made from a metal having a resistivity smaller than the resistivity of the metal of the said one part of that fusible element.

To enable the electric fuse, provided by the present invention, to keep potentially hurtful low overloads from injuring the electric devices in the circuit protected by that fuse, that fuse must be able to open that circuit promptly. The present invention makes it possible for that fuse to open the circuit promptly by sub-dividing the fusible element of that fuse into a number of short, parallel-connected links and by mounting those links on a massive support of dielectric material which has a groove in the exterior thereof. The sub-dividing of the fusible element into a number of short, parallel-connected links enables that fusible element to have a smaller mass than that fusible element would have if it were not sub-divided; and that smaller mass enables the fusible element to fuse more rapidly than it could if it were not sub-divided. The massive support of dielectric material absorbs substantial quantities of heat from those portions of the links which are tightly held in intimate engagement with it, and thus keeps the greater portions of the lengths of those links relatively cool. The groove in that support enables those portions of the links which span it to become quite hot; and the temperatures of those portions of those links will, whenever the fuse is carrying its rated current, be close to the temperature at which those links can start opening the circuit. The overall result is that while the greatest portion of the lengths of the links will be kept relatively cool—and thus can help extinguish any arcs that form as the fuse opens—the portions of the links which span the groove can respond to the rated current of the fuse to operate at temperatures close to the temperature at which those links can start opening the circuit and can respond to potentially hurtful overloads to rapidly reach the temperatures at which they can start opening the circuit. It is, therefore, an object of the present invention to provide a fuse wherein the fusible element is sub-divided into a number of short, parallel-connected links that are mounted on a massive support of dielectric material which has a groove in the exterior thereof.

To remain relatively cool, the portions of the links of the fuse which engage the massive support of dielectric material must remain in tight and intimate engagement with that support. If those links were mono-metallic in nature, the portions thereof which span the groove in the support and which respond to the flow of the rated current through the fuse to operate at temperatures close to the temperature at which those links can start opening the circuit would experience such a lessening of the tensile strength thereof that a tight and intimate engagement could not be maintained between the remaining portions of those links and the said support. However, because the links of the present invention are bi-metallic in nature and because one of the metals of those links has a tensile strength which is substantially undiminished at temperatures up to and including the temperature at which the other metal of those links melts and starts the opening of the circuit, those links are able to remain in tight and intimate engagement with that support. It is, therefore, an object of the present invention to provide a fuse wherein the fusible element remains in tight and intimate engagement with a massive support even though some portions of that fusible element respond to the flow of the rated current through the fuse to operate at temperatures close to the temperature at which those portions can start opening the circuit.

The electric fuse provided by the present invention has connectors that are massive relative to the links of that fuse, and those connectors directly engage those links. As a result, those connectors help the massive support of dielectric material keep the greatest portions of the lengths of those links relatively cool. It is, therefore, an object of the present invention to provide an electric fuse with a massive support of dielectric material and with relatively massive connectors which directly engage the links of that fuse.

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 a preferred embodiment of the present invention is 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 support of dielectric material for one form of electric fuse that is made in accordance with the principles and teachings of the present invention,

FIG. 2 is an elevational view of the left-hand end of the support of FIG. 1,

FIG. 3 is a front elevational view of the support of FIG. 1 after it has had connectors secured thereto and has had a fusible element secured to those connectors,

FIG. 4 is an elevational view of the left-hand end of the support, the fusible element and the connectors of FIG. 3,

FIG. 5 is a vertical section through a preferred form of electric fuse which includes the support, the connectors and the fusible element of FIGS. 3 and 4,

FIG. 6 is a sectional view through the electric fuse of FIG. 5, and it is taken along the plane indicated by the line **6**—**6** in FIG. 5,

FIG. 7 is an elevational view of the left-hand end of one of the terminals for the electric fuse of FIG. 5,

FIG. 8 is a sectional view through the terminal of FIG. 7, and it is taken along the plane indicated by the line **8**—**8** in FIG. 7, and

FIG. 9 is a sectional view, on a larger scale, through the fusible element of FIGS 3–5.

Referring to the drawing in detail, the numeral **10** denotes a support of dielectric material, and that dielectric material should be substantially unaffected by heat or by electric arcs, and it should be dimensionally stable. One material that has been found to be very useful is steatite.

The support **10** is generally cylindrical, and it has a generally circular cross section. However, that support has semi-cylindrical, elongated grooves **12**, **14**, **16** and **18** formed in the surface thereof. Those grooves are parallel to the geometric axis of the support **10**; and the grooves **12** and **16** are disposed at the ends of one diameter of that support while the grooves **14** and **18** are disposed at the ends of another diameter of that support. In the preferred form of the present invention, the width of each groove is less than one-thirteenth of the circumference of the support **10**. In that preferred form, the said dielectric support **10** is about one and thirty-six thousandths of an inch long and is about one hundred and eighty-five thousandths of an inch in diameter. The width and depth of each groove is about forty-three thousandths of an inch.

The numeral **20** denotes a J-shaped connector which is preferably made from a length of stiff wire of copper or the like. The diameter of the wire used in making the connector **20** is preferably just slightly less than the diameter of the grooves **12** and **16**; and, in the preferred form of the present invention, is about forty thousandths of an inch. Furthermore, the center-to-center distance of the arms of the J-shaped connector **20** is preferably equal to the center-to-center distance of the grooves **12** and **16**. As a result, the long arm of the connector **20** can be lodged within the groove **12** while the short arm of that connector can be lodged within the groove **16**. The numeral **22** denotes a second connector which is substantially identical to the connector **20**. However, the short arm of the connector **22** is lodged within the groove **12**

while the long arm of the connector **22** is lodged within the groove **16**. The connectors **20** and **22** are dimensioned so the long arm of the connector **20** is spaced an appreciable distance from the short arm of the connector **22** and so the long arm of the connector **22** is spaced an appreciable distance from the short arm of the connector **20**. Those spacings are long enough to prevent any leakage of current between the connectors **20** and **22**.

The numeral **24** generally denotes a fusible element which has a central core **23** and a coating **25**. That central core preferably is an elongated wire which is made from a metal that has a high melting point and a higher vaporizing temperature and that has a high tensile strength. While different metals could be used in making the core **23**, tungsten has been found to be very useful. The coating **25** has a melting point considerably below the melting point of the metal of the core **23**; and that coating is preferably made from one or more metals that can be electroplated onto that core but which will not tend to alloy with the metal of that core. Where the coating **25** includes two metals, those metals will preferably be formed as separate layers or sheaths. Where the coating **25** has just one metal therein, that metal can be copper. Where that coating has two metals therein, one can be copper and the other can be silver.

For clarity of illustration, the fusible element **24** has been shown much larger than it is in actual practice. In the said preferred embodiment of the present invention, the core **23** for the fusible elements **24** of one through five ampere fuses is a number fifty tungsten wire; and the core **23** for the fusible elements **24** of seven through nine ampere and fifteen ampere fuses is a number forty-eight tungsten wire. The fusible element **24** for the one ampere fuse has just enough copper electroplated onto the core **23** to reduce the resistance of that fusible element to about thirty-five ohms per foot. The fusible element **24** for the two ampere fuse has just enough copper electroplated onto the core **23** to reduce the resistance of that fusible element to about eighteen ohms per foot. The fusible element **24** for the three ampere fuse has just enough copper electroplated onto the core **23** to reduce the resistance of that fusible element to about fourteen ohms per foot. The fusible element **24** for the four ampere fuse or the five ampere fuse has just enough copper electroplated onto the core **23** to reduce the resistance of that fusible element to about ten and one-half ohms per foot. The fusible element **24** for the seven ampere fuse or the eight ampere fuse has just enough copper electroplated onto the core **23** to reduce the resistance of that fusible element to about seven and one-quarter ohms per foot. The fusible element **24** for the nine ampere fuse has just enough copper electroplated onto the core **23** to reduce the resistance of that fusible element to about six and one-half ohms per foot. The fusible element **24** for the fifteen ampere fuse has just enough copper electroplated onto the core **23** to reduce the resistance of that fusible element to about seven and one-quarter ohms per foot and then has enough silver electroplated onto the copper to reduce the overall resistance of that fusible element to about two and one-half ohms per foot. The fusible elements **24** for larger amperage fuses will use larger diameter cores **23** and will use thicker coatings **25**. As a general rule, where the fusible element **24** consists of a tungsten core **23** and a copper coating **25**, the weight of the coating **25** should be from about eighty to about one hundred percent of the weight of the core **23**. Where the fusible element **24** consists of a tungsten core **23** and a coating **25** which includes a copper layer and an external silver layer, the weight of the copper layer should be from about eighty to about one hundred percent of the weight of the core **23** and the weight of the silver layer should be from about one hundred and seventy to about one hundred and fifty percent of the weight of that core. These weight relationships are not practically attainable in electric fuses with ratings of less than ten amperes, because tungsten wire of the requisite minute diameter is not commercially available. However, those weight relationships can and should be used in larger fuses. In each fuse, regardless of its ampere rating, the support **10** should be made large enough to be massive relative to the fusible element.

The fusible element **24** is arranged to act as a plurality of short, parallel-connected links. Specifically, that fusible element is wound in helical fashion onto the support **10**; and the various turns of that fusible element engage and are bonded to the long arms of the connectors **20** and **22**. A mass **26** of solder bonds the turns of that fusible element to the connector **20**, and a mass **28** of solder bonds those turns to the connector **22**. The fusible element **24** is wound tightly onto the support **10**, and the various turns thereof are held in intimate engagement with the periphery of that support as the masses **26** and **28** are used to bond those turns to the long arms of connectors **20** and **22**. The intimate engagement between fusible element **24** and support **10** is important because it enables substantial amounts of the heat generated by that fusible element to be absorbed by that support.

While the greatest portions of the length of each turn of fusible element **24** are in intimate engagement with the periphery of support **10**, the portions of those turns which span the grooves **14** and **18** are not in engagement with the periphery of that support. As a result, those latter portions can become quite hot; and, preferably, the temperatures of those latter portions will, whenever the rated current flows through fusible element **24**, be close to the melting temperature of coating **25**.

The number of turns of the fusible element **24** will vary with the ampere rating of the fuse. For example, in the preferred form of the present invention, the one ampere fuse has one and one-half turns, the two ampere fuse and the three ampere fuse each has two turns, the four ampere fuse has three turns, the five ampere fuse has three and one-half turns, the seven ampere fuse has three and one-half turns, the eight ampere fuse has four and one-half turns, the nine ampere fuse has four turns, and the fifteen ampere fuse has three and one-half turns. By appropriate selection of the number of turns, and by appropriate selection of the weights of the cores **23** and the coatings **25**, it is possible to make fuses of any desired ampere rating.

The support **10**, the connectors **20** and **22**, the fusible element **24**, and the masses of solder **26** and **28** constitute a sub-assembly which is sturdy and rugged. That sub-assembly can readily be handled as a unit.

The numeral **32** denotes a generally cup-shaped terminal which has a recessed end wall. An elongated rectangular slot **34** is formed in the recessed end wall of the terminal **32**, and that slot is dimensioned to accommodate the closed end of the J-shaped connector **20**—all as shown by FIG. 5. The numeral **36** denotes a cup-shaped terminal which has a recessed end wall; and an elongated rectangular slot **38** is formed in that recessed end wall. The slot **38** is dimensioned to accommodate the closed end of the J-shaped connector **22**, all as shown by FIG. 5.

The numeral **30** denotes a casing of dielectric material. That casing has an inner diameter which is larger than the diameter of the support **10**; and it has an outer diameter which is just slightly smaller than the inner diameters of the terminals **32** and **36**.

In assembling the electric fuse provided by the present invention, the connectors **20** and **22** are set within the grooves **12** and **16** in the support **10**; and thereafter the fusible element **24** is wound into intimate engagement with the support **10** and with the connectors **20** and **22**. That fusible element is then maintained in intimate engagement with that support and with those connectors while the masses **26** and **28** of solder are used to bond that fusible element to those connectors. The resulting sub-assembly can then be telescoped into the casing **30**.

The terminal 32 can have the slot 34 therein alined with the closed end of the connector 20, and then the open end of that terminal can be telescoped over the left-hand end of the casing 30. That open end can, at such time, be crimped to fixedly secure it to the casing 30. Thereupon the terminal 36 can have the slot 38 therein alined with the closed end of the connector 22, and can have the open end thereof telescoped over the right-hand end of the casing 30. That open end can, at that time, be crimped into permanent engagement with the casing 30. Solder 40 can be used to bond the J-shaped connector 20 to the terminal 32, and further solder 42 can be used to bond the J-shaped connector 22 to the terminal 36. The terminals 32 and 36 are dimensioned to fit into standard fuse clips.

In the normal operation of the electric fuse provided by the present invention, current will flow from terminal 32 via solder 40, connector 20, solder mass 26, the short, parallel-connected links which are defined by the fusible element 24 and are shown by solid lines in FIG. 3 and the short, parallel-connected links which are defined by the fusible element 24 and are shown by dotted lines in FIG. 3, the solder mass 28, connector 22, and solder 42 to the terminal 36. The flow of current through the links defined by the fusible element 24 will cause those links to generate heat. Because the greatest portions of the lengths of those links are held tightly in intimate engagement with the periphery of the support 10 or with the connectors 20 and 22, those portions will remain relatively cool. However, those portions of the lengths of the links which span the grooves 14 and 18 will become quite hot. In fact, when the fuse of FIGS. 5 and 6 is carrying its rated current, the temperatures of the portions of the links which span the grooves 14 and 18 will be close to the melting point of the coating 25. However, as long as the current passing through that fuse does not exceed the rated current of that fuse, the links defined by the fusible element 24 will remain intact.

In the event the current flowing through the fuse of FIGS. 5 and 6 exceeds the rated current by a predetermined amount—and that amount can be as low as ten percent of the rated current—the temperatures of those portions of the links which span the grooves 14 and 18 will reach the melting point of the coating 25. Thereupon, those portions of the coating 25 will melt, and will flow or draw away from those portions of the core 23 which they initially encased. As those portions of the coating 25 melt, the resistances thereof will increase; and this means that the overall resistances of the various links will increase. This is desirable because it will tend to keep a hurtful current surge from developing. Also, as the said portions of the coating 25 melt, the cores 23 of the links will have to carry higher percentages of the current; and those cores will get hotter because of that fact. As the said portions of the coating 25 flow or draw away from the portions of the cores 23 which they initially encased, the overall resistances of the various links will again increase. This is desirable because it will tend to keep a hurtful current surge from developing. Also, as the said portions of the coating 25 draw or flow away, the said portions of the cores 23 will be subjected to the full current overload; and those portions of those cores will promptly melt. As those portions of the cores 23 melt, the overall resistances of the links will increase once again. This is desirable because it will tend to keep a current surge from developing. Very promptly, the said portions of the cores 23 will vaporize; and, immediately, arcs will form, because the temperatures of the vapors of those portions of those cores will be close to the thermal ionization temperatures of the metal of those cores. Those arcs will avoid an abrupt rise in the voltage across the fuse of FIGS. 5 and 6, and will thus tend to keep a hurtful voltage surge from developing. The arcs will be quickly extinguished because the support 10, and those portions of the fusible element 24 which intimately engage that support, will be cool and can quickly de-ionize those arcs. The overall result is that the fuse of FIGS. 5 and 6 can respond to potentially hurtful current overloads and open the circuit without permitting hurtful current surges or hurtful voltage surges to develop.

In providing progresive increases in the overall resistance of the fusible element 24, the coating 25 and the core 23 not only tend to keep hurtful current surges from developing, but they also tend to keep hurtful voltage surges from developing. Specifically, those progressive increases in the overall resistance of the fusible element 24 limit the rate of change of the current in the circuit, and thus reduce the value of the voltage which can be induced in that circuit. The overall result is that the fuse provided by the present invention can respond to potentially hurtful current overloads to open the circuit without permitting hurtful current surges or hurtful voltage surges to develop.

Where desired, arc-extinguishing filler material, not shown, can be disposed in the space between the support 10 and the interior of the casing 30. That filler material will embed the portions of the links which span the grooves 14 and 18, and will help extinguish the arcs that form as those portions fuse. In most sizes of fuses provided by the present invention, filler material will be wholly unnecessary because of the relative massiveness of the support 10. Even in the thirty ampere fuse provided by the present invention, the overall diameter of the copper and silver coated fusible element 24 is only twenty-six ten-thousandths of an inch; and the arcs which form when portions of that fusible element fues are quickly de-ionized by the relatively cool support 10 and by those portions of the links which are tightly held in intimate engagement with that support.

While tungsten is particularly useful as the metal for the core 23, because of its high vaporizing temperature, its workability, and its commercial availability, other metals could be used. If they could be commercially obtained as wire of the required diameter, metals such as iridium, osmium, molybdenum, rhenium, tantalum, titanium, yttrium and zirconium could be used in making the core 23.

Whereas the drawing and accompanying description have shown and described one preferred embodiment 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. An electric fuse which comprises:
   (a) terminals that are connectable into an electric circuit,
   (b) a fusible element electrically connected to said terminals to conduct current between said terminals,
   (c) said fusible element responding to overloads of predetermined magnitude and duration to fuse,
   (d) a massive support of dielectric material that supports said fusible element and that absorbs heat from said fusible element,
   (e) connectors connecting said fusible element to said terminals,
   (f) said connectors being generally J-shaped,
   (g) said support having a groove therein to accommodate the long arm of one of said connectors and to accommodate the short arm of a second of said connectors,
   (h) said support having a second groove therein to accommodate the long arm of said second connector and to accommodate the short arm of said one connector,
   (i) said support having a third groove intermediate the first said and said second grooves,
   (j) said fusible element spanning said third groove.

2. An electric fuse which comprises:
(a) terminals that are connectable into an electric circuit,
(b) a fusible element electrically connected to said terminals to conduct current between said terminals,
(c) said fusible element responding to overloads of predetermined magnitude and duration to fuse,
(d) a massive support of dielectric material that supports said fusible element and that absorbs heat from said fusible element,
(e) connectors connecting said fusible element to said terminals,
(f) said support having a groove therein which extends transversely of said fusible element and which accommodates one of said connectors,
(g) said support having a second groove therein which extends transversely of said fusible element and which accommodates a second connector,
(h) said support having a third groove therein which extends transversely of said fusible element and which is intermediate the first said and said second grooves,
(i) said fusible element having a portion thereof spanning said third groove and having elongated portions that are contiguous with said spanning portion and that intimately engage said support,
(j) said support absorbing substantial amounts of heat from said contiguous portions of said fusible element,
(k) said spanning portion of said fusible element having much less heat absorbed from it than do said contiguous portions of said fusible element,
(l) whereby said spanning portion of said fusible element is hotter than said contiguous portions of said fusible element,
(m) said fusible element responding to overloads of predetermined magnitude and duration to cause said spanning portion thereof to promptly fuse.

3. An electric fuse which comprises:
(a) terminals that are connectable into an electric circuit,
(b) a fusible element electrically connected to said terminals to conduct current between said terminals,
(c) said fusible element responding to overloads of predetermined magnitude and duration to fuse,
(d) a massive support of dielectric material that supports said fusible element and that absorbs heat from said fusible element,
(e) said support defining a space that is spanned by a portion of said fusible element,
(f) the portions of said fusible element which are contiguous to said spanning portion of said fusible element being elongated and being held in intimate engagement with the surface of said support,
(g) whereby said contiguous portions of said fusible element will be kept relatively cool and will be resistant to fusing,
(h) said spanning portion of said fusible element having much less heat absorbed from it than is absorbed from said contiguous portions of said fusible element,
(i) whereby said spanning portion of said fusible element is hotter than said contiguous portions of said fusible element,
(j) said fusible element being dimensioned so the temperature of said spanning portion thereof will be close to the fusing temperature thereof when rated current flows through said fusible element.

4. An electric fuse which comprises:
(a) terminals that are connectable into an electric circuit,
(b) a fusible element electrically connected to said terminals to conduct current between said terminals,
(c) said fusible element having a plurality of sections that are connected in parallel with each other,

(d) said fusible element responding to overloads of predetermined magnitude and duration to fuse,
(e) a massive support of dielectric material that supports said sections of said fusible element and that absorbs heat from said sections of said fusible element,
(f) said support defining a space that is spanned by a portion of each of said sections of said fusible element,
(g) the portions of each section of said fusible element which are contiguous to said spanning portion of said section of said fusible element being elongated and being held in intimate engagement with the surface of said support,
(h) whereby said contiguous portions of said sections of said fusible element will be kept relatively cool and will be resistant to fusing,
(i) said spanning portions of said sections of said fusible element having much less heat absorbed from them than is absorbed from said contiguous portions of said sections of said fusible element,
(j) whereby said spanning portions of said sections of said fusible element are hotter than said contiguous portions of said sections of said fusible element,
(k) said sections of said fusible element being dimensioned so the temperature of the spanning portion of each of said sections of said fusible element will be close to the fusing temperature thereof when rated current flows through said fusible element,
(l) whereby said spanning portions of said sections of said fusible element will promptly fuse on very low overloads.

5. An electric fuse which comprises:
(a) terminals that are connectable into an electric circuit,
(b) a fusible element electrically connected to said terminals to conduct current between said terminals,
(c) said fusible element responding to overloads of predetermined magnitude and duration to fuse,
(d) a massive support of dielectric material that supports said fusible element and that absorbs heat from said fusible element,
(e) said support defining a space that is spanned by a portion of said fusible element,
(f) the portions of said fusible element which are contiguous to said spanning portion of said fusible element being elongated and being held in intimate engagement with the surface of said support,
(g) whereby said contiguous portions of said fusible element will be kept relatively cool and will be resistant to fusing,
(h) said spanning portion of said fusible element constituting only a minor portion of the length of said fusible element,
(i) said contiguous portions of said fusible conductor constituting the major portion of the length of said fusible element,
(j) whereby the major portion of the length of said fusible conductor is kept relatively cool and resistant to fusing,
(k) said spanning portion of said fusible element having much less heat absorbed from it than is absorbed from said contiguous portions of said fusible element,
(l) whereby said spanning portion of said fusible element is hotter than said contiguous portions of said fusible element,
(m) said spanning portion of said fusible element having, because of the elevated temperature thereof, a greater resistivity than the resistivity of any of said contiguous portions of said fusible element,
(n) said fusible element being dimensioned so the temperature of said spanning portion thereof will be close to the fusing temperature thereof when rated current flows through said fusible element.

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