

[54] PROTECTOR FOR ELECTRIC CIRCUITS

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[22] Filed: July 23, 1973

[21] Appl. No.: 381,996

[52] U.S. Cl. .... 337/165, 337/166

[51] Int. Cl. .... H01h 71/20

[58] Field of Search ..... 337/159, 163, 165, 166, 337/78, 238

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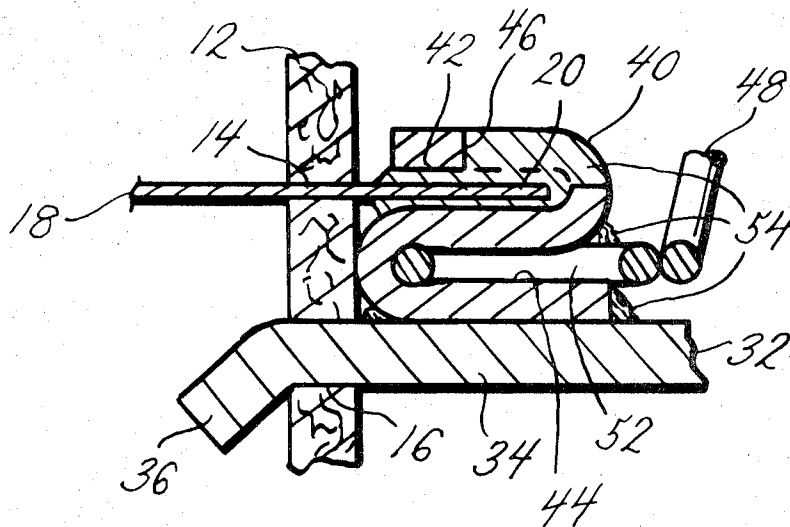
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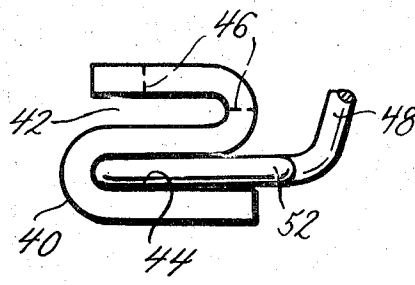
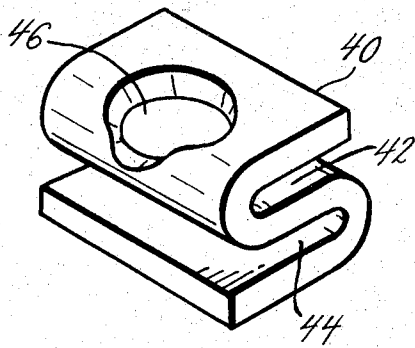
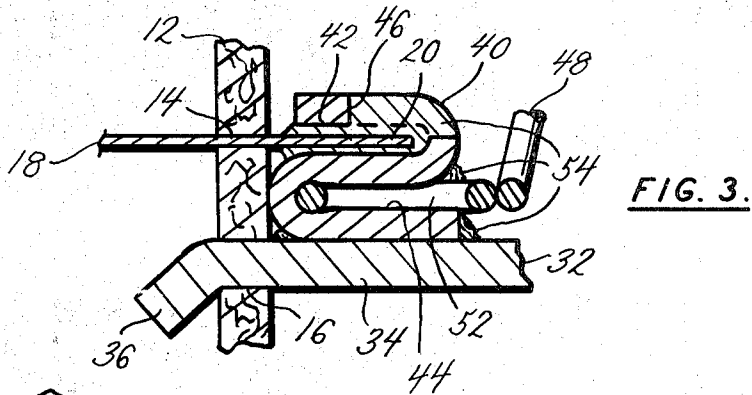
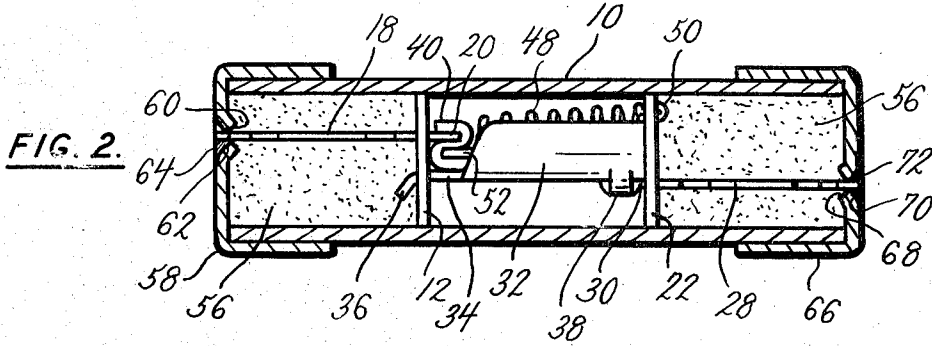
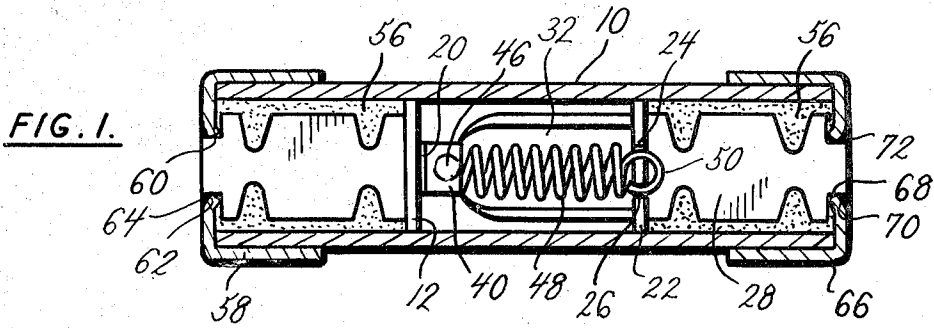
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[57] ABSTRACT

A generally S-shaped connector defines a generally U-shaped recess for one end of a fusible element of a dual-element cartridge-type electric fuse, defines a second generally U-shaped recess in which one end of the helical extension spring of that electric fuse can be held, and is bonded to that end of that fusible element and to one end of the heat-absorbing member of that electric fuse by a mass of low-melting point alloy. That generally S-shaped connector is made from a single piece of metal to assure optimum electrical and thermal interchange between that fusible element, that connector and that heat-absorbing member.

5 Claims, 5 Drawing Figures





## PROTECTOR FOR ELECTRIC CIRCUITS

## 1. Field of the Invention

This invention relates to a dual-element cartridge-type electric fuse wherein a connector is normally held in position between a fusible element and a heat-absorbing member by a low-melting point alloy, and wherein a spring will move that connector out of that position before any potentially-hurtful electrical overloads can continue long enough to become hurtful.

## 2. Description of the Prior Art

Duerkob Pat. No. 2,300,620 discloses a dual-element cartridge-type electric fuse which has a fusible element adjacent one end thereof, has a heating element adjacent the other end thereof, has a heat-absorbing member adjacent the middle thereof, and has a connector which is normally held in position between one end of that fusible element and one end of that heat-absorbing member by a low-melting point alloy. A spring biases that connector for movement out of that position, and that spring will move that connector out of that position when the low-melting point alloy softens in response to potentially-hurtful electrical overloads. That connector is made of two U-shaped pieces of metal of different thickness and of different hardness.

## SUMMARY OF THE INVENTION

A generally S-shaped connector defines a generally U-shaped recess for one end of a fusible element of a dual-element cartridge-type electric fuse, defines a second generally U-shaped recess in which one end of the helical extension spring of that electric fuse can be held, and is bonded to that end of that fusible element and to one end of the heat-absorbing member of that electric fuse by a mass of low-melting point alloy. That generally S-shaped connector is made from a single piece of metal of homogeneous nature and of constant width and thickness; and hence that connector is free of thermal and electrical interfaces and is able to provide optimum electrical and thermal interchange between that fusible element and that heat-absorbing element.

## BRIEF DESCRIPTION OF THE DRAWING

In the drawing, FIG. 1 is a longitudinal section through a dual-element cartridge-type electric fuse which has incorporated therein the generally S-shaped connector provided by the present invention.

FIG. 2 is a longitudinal section through the electric fuse of FIG. 1 which is taken at right angles to the section of FIG. 1,

FIG. 3 is a vertical section, on a larger scale, through the inner end of the left-hand fusible element, through the left-hand end of the heat-absorbing member, and through the connector of the electric fuse of FIGS. 1 and 2,

FIG. 4 is a side elevational view, on the scale of FIG. 3, of the connector and of the left-hand end of the spring of the electric fuse of FIGS. 1 and 2 before the lower generally U-shaped recess of that connector is closed to clamp that end of that spring, and

FIG. 5 is a perspective view, on a still larger scale, of the connector of the electric fuse of FIGS. 1 and 2 after that connector has been rotated about 150° from the position shown in FIG. 4.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing in detail, the numeral 10 denotes the housing of a dual-element cartridge-type electric fuse; and that housing will be of insulating material such as fiber or the like. The numeral 12 denotes a disk-like partition of circular configuration which has an upper slot 14 therein and which has a lower slot 16 therein, as shown particularly by FIG. 3. That disk-like partition will be of insulating material such as fiber or the like. The diameter of the disk-like partition 12 is just slightly smaller than the inner diameter of the housing 10, and hence that disk-like partition will act as a separator between the areas which are within the housing 10 at opposite sides of that disk-like partition.

The numeral 18 denotes a fusible element which has two "weak spots" intermediate the ends thereof; and those weak spots are shown as being defined by two sets of oppositely-disposed inwardly-extending notches. The numeral 20 denotes the inner end of that fusible element, and that inner end extends through and is supported by the upper slot 14 in the disk-like partition 12, as shown particularly by FIG. 3. The numeral 22 denotes a disk-like partition of circular configuration which has notches 24 and 26 in the upper edge thereof, and which has a slot, not shown, in the lower portion thereof. That disk-like partition will be of insulating material such as fiber or the like. The diameter of the disk-like partition 22 is just slightly less than the inner diameter of the housing 10, and hence that disk-like partition will act as a separator between the areas which are within the housing 10 at opposite sides of that disk-like partition.

The numeral 28 denotes a fusible element which can be identical to the fusible element 18. As shown particularly by FIG. 1, the fusible element 28 has two weak spots intermediate the ends thereof; and those weak spots are shown as being defined by two sets of oppositely-disposed inwardly-extending notches. The numeral 30 denotes the inner end of the fusible element 28, and that inner end extends through the slot, not shown, in the lower portion of the disk-like partition 22. The numeral 32 denotes a trough-shaped heat-absorbing element which has a tang 34 at the left-hand end thereof, as shown particularly by FIG. 2. The left-hand end 36 of that tang extends through the lower opening 16 in the disk-like partition 12 and then inclines downwardly, as shown particularly by FIG. 3. The downwardly-inclined end 36 on the tang 34 of the heat-absorbing member 32 will enable that heat-absorbing member to resist any tendency of the disk-like partition 12 to rotate in the clockwise direction in FIGS. 2 and 3. The right-hand end of the lower surface of the heat-absorbing member 32 has a loop 38 punched downwardly below the surface thereof, as indicated particularly by FIG. 2. That loop defines a slot into which the left-hand end 30 of the fusible element 28 extends.

The numeral 40 denotes a generally S-shaped connector which is made from a unitary piece of metal of good conductivity, such as copper; and that connector has a uniform width and thickness. That connector defines a generally U-shaped upper recess 42 which opens to the left in FIG. 4 and opens to the right in FIG. 5; and that connector also defines a generally U-shaped lower recess 44 which opens to the right in FIG. 4 and opens

to the left in FIG. 5. The numeral 46 denotes a generally-circular opening in the top of the connector 42 which provides access to the generally U-shaped upper recess 42. As indicated particularly by FIG. 3, the vertical dimension of the generally U-shaped upper recess 42 is greater than the thickness of the right-hand end 20 of the fusible element 18; and that vertical dimension is great enough to facilitate prompt and sure movement of the connector 40 away from that right-hand end whenever that connector is supposed to move away from that right-hand end.

The numeral 48 denotes a helical extension spring that has a loop 50 at the right-hand end thereof which fits down into the notches 24 and 26 in the upper edge of the disk-like partition 22. The helical extension spring 48 has a loop 52 at the other end thereof, and that loop is dimensioned to fit within the generally U-shaped lower recess 44 in the connector 40. As indicated by FIGS. 2 and 3, the lower portion of the connector 40 is compressed to force the intermediate and bottom portions of that connector into clamping relation with the loop 52 of the spring 48. Further, as indicated by FIG. 3, the confronting faces of the middle and bottom portions of that connector cold-flow into the area which is defined by the loop 52 of the spring 48 during the compression of those intermediate and lower portions into clamping engagement with that loop. This means that the total free space between the confronting faces of the intermediate and lower portions of the connector 40 is quite small.

The numeral 54 denotes low-melting point alloy that fills the portion of the generally U-shaped upper recess 42 which is not occupied by the right-hand end 20 of the fusible element 18, fills the portion of the compressed U-shaped recess 44 which is not filled by the loop 52 of the spring 48, and which normally bonds the connector 40 to the left-hand end of the heat-absorbing element 32 and to the right-hand end 20 of the fusible element 18. The numeral 56 denotes arc-extinguishing filler which is located in the space in the housing 10 to the left of the disk-like partition 12, and which is located in the space in that housing to the right of the disk-like partition 22. That arc-extinguishing filler will surround the portion of the fusible element 18 which is located to the left of the disk-like partition 12, and also will surround the portion of the fusible element 28 which is located to the right of the disk-like partition 22. That arc-extinguishing filler will facilitate the prompt quenching of any arcs which develop as either or both of those fusible elements fuse to open the circuit.

The numeral 58 denotes a ferrule-type end cap which is dimensioned to telescope over the left-hand end of the casing 10. A slot 60 is formed in the end wall of that end cap, and a shallow recess 62 is formed in the outer surface of that end wall as the slot 60 is formed. The left-hand end of the fusible element 18 will extend through the slot 60 and then will be cut off. Solder 64 will fill the recess 62 and will bond the left-hand end of the fusible element 18 to the end cap 58. The numeral 66 denotes a ferrule-type end cap which is dimensioned to telescope over the right-hand end of the casing 10. A slot 68 is formed in the end wall of that end cap, and a shallow recess 70 is formed in the outer surface of that end wall as the slot 68 is formed. The right-hand end of the fusible element 28 will extend through the slot 68 and then will be cut off. Solder 72 will fill the

recess 70 and will bond the right-hand end of the fusible element 28 to the end cap 66. The free edges of the end caps 58 and 66 will be suitably cold-formed into the outer surface of the casing 10 to permanently secure those end caps to that casing.

The housing 10, the disk-like partitions 12 and 22, the fusible elements 18 and 28, the heat-absorbing member 32, the helical extension spring 48, and the end caps 58 and 66 have been used for a number of years in dual-element electric fuses marketed by the Bussmann Mfg. Division of the McGraw-Edison Company, assignee of the present application; and hence they are not, per se, parts of the present invention. In one preferred embodiment of the present invention, the connector 40 is made by cold-forming a flat strip of "dead soft" copper of rectangular cross section into the S-shaped configuration emphasized by FIG. 4. Where the electric fuse of FIG. 1 and 2 is a 60 ampere 250 volt fuse, that flat strip of copper is two hundred and fifty thousandths of an inch wide and is forty thousandths of an inch thick. The opening 46 has a diameter of approximately one hundred and twenty-five thousandths of an inch, and that opening preferably is punched in the flat strip of copper before that strip is cold-formed to have the S-shaped configuration of FIGS. 4 and 5. The connector 40 has a total weight of nine hundred and ninety-five thousandths of a gram; and that weight is 21 and 8/10ths. percent greater than the weight of the corresponding connector used in the said Duerkob patent. Such an increase is important in increasing the transfer of heat, which is generated by the weak spots in the fusible element 18, through the connector 40 to the heat-absorbing member 32.

By being punched from a unitary piece of metal, the connector 40 constitutes a continuous strip of metal of homogeneous nature, and thus is free from electrical and thermal interfaces. The absence of an electrical interface in the connector 40 enables that connector to have minimal resistance to the flow of electric current through it, and thus minimizes the generation of heat by that connector as current flows through it. A comparison of the electrical resistances of eight connectors 40 for a given size fuse with the electrical resistances of eight two-piece connectors for the same size fuse of the said Duerkob patent shows that the absence of an electrical interface greatly reduces the electrical resistance of a connector:

Electrical Resistance of Connectors 40	Electrical Resistance of Duerkob Patent Connectors
.000059	.000720
.000053	.000240
.000069	.000760
.000054	.000360
.000048	.000390
.000064	.000660
.000050	.000250
.000047	.000300

The average electrical resistance of the connectors 40 is less than one eighth of the average electrical resistance of the connectors of the said Duerkob patent. The absence of a thermal interface in the connector 40 enables that connector to have minimal resistance to the flow of heat from fusible element 18 through it to the heat-absorbing member 32. Electrical and thermal interfaces in the connectors of dual-element cartridge-type electric fuses inherently and necessarily cause

those electric fuses to open faster on given overloads, and thus tend to cause those electric fuses to "fail safe". However, those electrical and thermal interfaces tend to decrease the ability of those electric fuses to avoid needless "blows", and hence the connector 40 makes it possible to provide an electric fuse that is just as safe as the electric fuse of the said Duerkob patent but which has a more precisely-predictable time delay. Such an electric fuse is desirable because it facilitates more precise "sizing" of the electric fuses in a coordinated electrical protection system.

The confronting faces of the intermediate and bottom portions of the connector 40 directly confront the loop 52 of the spring 48, as shown particularly by FIG. 4, and those faces are relatively yieldable because the connector 40 is made from "soft" copper. As a result, when the generally U-shaped lower recess 44 is compressed to effectively clamp the loop 52 of the spring 48, the confronting faces of the intermediate and bottom portions of the connector 40 can move closer to each other than can the confronting faces of the two specifically different parts which define the generally U-shaped lower recess of the connector of the said Duerkob patent. The resulting increased proximity of the confronting faces of the intermediate and bottom portions of the connector 40 is desirable in reducing the total amount of low-melting point alloy which must be used to fill the void between those confronting faces, and also is desirable in reducing the total length of the electrical and thermal shunting path which that low-melting point alloy provides between those confronting faces.

By making the connector 40 from a unitary piece of metal, it is possible to shorten the distance from the outer end to the inner end of the generally U-shaped upper recess 42; and such shortening is desirable because it reduces the total distance through which current and heat must flow as they pass from the right-hand end 20 of the fusible element 18 through the upper portion of the connector 40 and then through the rest of that connector to the heat-absorbing member 32. That reduction in total distance increases the efficiency of the connector 40 in facilitating the transfer of current and heat from the fusible element 18 to the heat-absorbing member 32.

The opening 46 in the connector 40 is closer to the closed end than to the open end of the generally U-shaped upper recess 42, as indicated particularly by FIGS. 3-5. That opening facilitates the introduction of the low-melting point alloy into that recess in such a way that the said low-melting point alloy can quickly and effectively fill the inner end of that generally U-shaped upper recess.

By making the connector 40 from a single piece of metal, the present invention offers the possibility of increasing the thickness of that connector without increasing the spacing between the bottom of that connector and the generally U-shaped upper recess 42, or of leaving the thickness of that connector unchanged and of reducing the spacing between the bottom of that connector and the generally U-shaped upper recess 42. The possibility of increasing the thickness of the connector 40 without increasing the spacing between the bottom of that connector and the generally U-shaped upper recess 42 is attractive; because that increase in thickness would additionally reduce the electrical and thermal resistance of that connector, and the

continuance of that spacing would permit continued use of presently-used production line tools and fixtures. The possibility of reducing the spacing between the bottom of that connector and the generally U-shaped upper recess 42 is attractive; because that reduction in spacing would permit the fusible element 18 to be disposed closer to the axis of the housing 10. Consequently, it should be apparent that the making of the connector 40 from a single piece of metal offers distinct advantages to the manufacturer of the electric fuse of FIGS. 1 and 2.

It also should be noted that a one-piece connector 40 offers the possibility of automating the assembling of that connector with the loop 52 of the helical extension spring. Such a possibility is not offered by the two-piece connector of the said Duerkob patent; and hence the making of the connector 40 from a single piece of metal offers a still further distinct advantage to the manufacturer of the electric fuse of FIGS. 1 and 2.

Whereas the drawing and accompanying description have shown and described a 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. A heat-sensing circuit-opening protective device which comprises a metal heat-absorbing element, a metal conductor which has one end thereof coextensive with, but spaced away from, a portion of said metal heat-absorbing element, a spring, a generally S-shaped connector which defines a first generally U-shaped recess that freely accommodates said one end of said metal conductor and which defines a second generally U-shaped recess that accommodates one end of said spring in tightly-clamped relation, metal terminals which are electrically connected to said metal conductor and to said metal heat-absorbing member and which are connectable to an electric circuit, said spring biasing said connector for movement away from said one end of said metal conductor and away from said portion of said metal heat-absorbing element to interrupt said electric circuit, and a mass of low-melting point alloy that normally mechanically connects and electrically bonds said connector to said portion of said metal heat-absorbing element and that also normally mechanically connects and electrically bonds said connector to said one end of said metal conductor while holding the first said generally U-shaped recess telescoped over said one end of said metal conductor, said connector being a unitary piece of metal which is free of electrical and thermal interfaces, said low-melting point alloy responding to heat to permit said spring to move said connector away from said one end of said metal conductor and away from said portion of said metal heat-absorbing member and thereby interrupt said electric circuit.

2. A heat-sensing circuit-opening device as claimed in claim 1 wherein said generally S-shaped connector is made from dead soft copper to enable portions of both of the confronting faces of said generally U-shaped second recess to cold-flow into a loop defined by said one end of said spring and thereby leave a minimum of voids between said confronting faces of said generally U-shaped second recess.

3. A heat-sensing circuit-opening device which is part of a dual element fuse and which comprises a metal

heat-absorbing element, a readily-fusible metal conductor which has one end thereof coextensive with, but spaced away from, a portion of said metal heat-absorbing element, a spring, a generally S-shaped connector which defines a first generally U-shaped recess that freely accommodates said one end of said readily-fusible metal conductor and which defines a second generally U-shaped recess that accommodates one end of said spring, metal terminals which are electrically connected to said readily-fusible metal conductor and to said metal heat-absorbing element and which are connectable to an electric circuit, said spring biasing said connector for movement away from said one end of said readily-fusible metal conductor and away from said portion of said metal heat absorbing element to interrupt said electric circuit, and a mass of low-melting point alloy that normally mechanically connects and electrically bonds said connector to said portion of said metal heat-absorbing element and that also normally mechanically connects and electrically bonds said connector to said one end of said readily-fusible metal conductor while holding said first generally U-shaped recess telescoped over said one end of said readily-fusible metal conductor, said second U-shaped recess having a length approximately equal to the diameter of the loop at one end of said spring, said loop at said one end of said spring having one edge thereof closely adjacent the inner end of said second generally U-shaped recess and having the opposite edge thereof closely adjacent the outer end of said second generally U-shaped recess, said second generally U-shaped recess being tightly clamped onto said one end of said spring to permanently maintain said one end of said spring and said generally S-shaped connector as a unit, said connector being a unitary piece of metal which is free of electrical and thermal interfaces, said low-melting point alloy responding to heat to permit said spring to move said

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connector away from said one end of said readily-fusible metal conductor and away from said portion of said metal heat absorbing element and thereby interrupt said electric circuit.

4. A heat-sensing circuit-opening device as claimed in claim 1 wherein the top of said generally S-shaped connector has an opening therein adjacent the closed end of said first generally U-shaped recess.

5. A heat-sensing circuit-opening device which is part of a dual element fuse and which comprises a metal heat-absorbing element, a readily-fusible metal conductor which has one end thereof coextensive with, but spaced away from, a portion of said metal heat-absorbing element, a spring, a generally S-shaped connector which defines a first generally U-shaped recess that freely accommodates said one end of said readily-fusible metal conductor and which defines a second generally U-shaped recess that accommodates one end of said spring in tightly-clamped relation, metal terminals which are electrically connected to said readily-fusible metal conductor and to said metal heat-absorbing element and which are connectable to an electric circuit, said spring biasing said connector for movement away from said one end of said readily-fusible metal conductor and away from said portion of said metal heat absorbing element to interrupt said electric circuit, and a mass of low-melting point alloy that normally mechanically connects and electrically bonds said connector to said portion of said metal heat-absorbing element and that also normally mechanically connects and electrically bonds said connector to said one end of said readily-fusible metal conductor while holding said first generally U-shaped recess telescoped over said one end of said readily-fusible metal conductor, said connector being of constant width and thickness.

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