July 14, 1959 F. J. KOZACKA 2,895,031

FUSIBLE PROTECTIVE DEVICES

Filed July 24, 1958 2 Sheets-Sheet 1

Fig. 1.

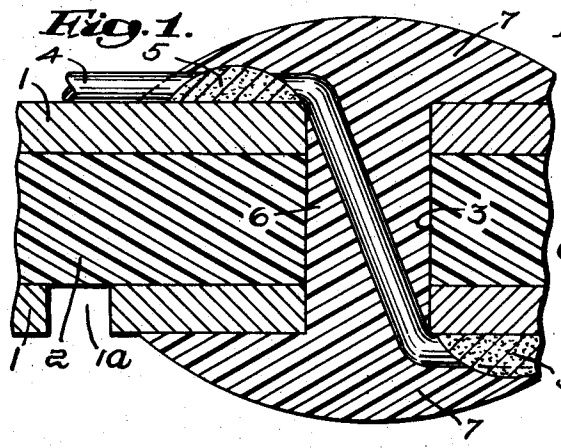


Fig. 2.

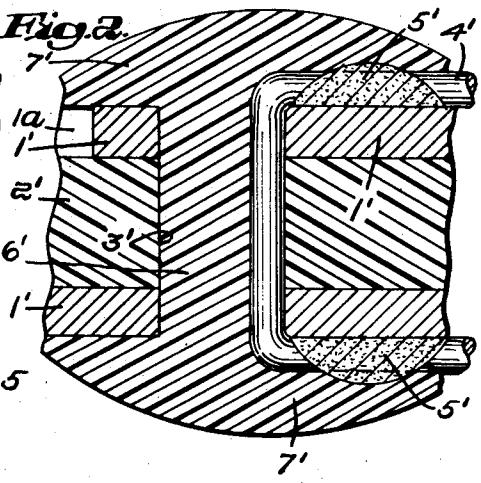
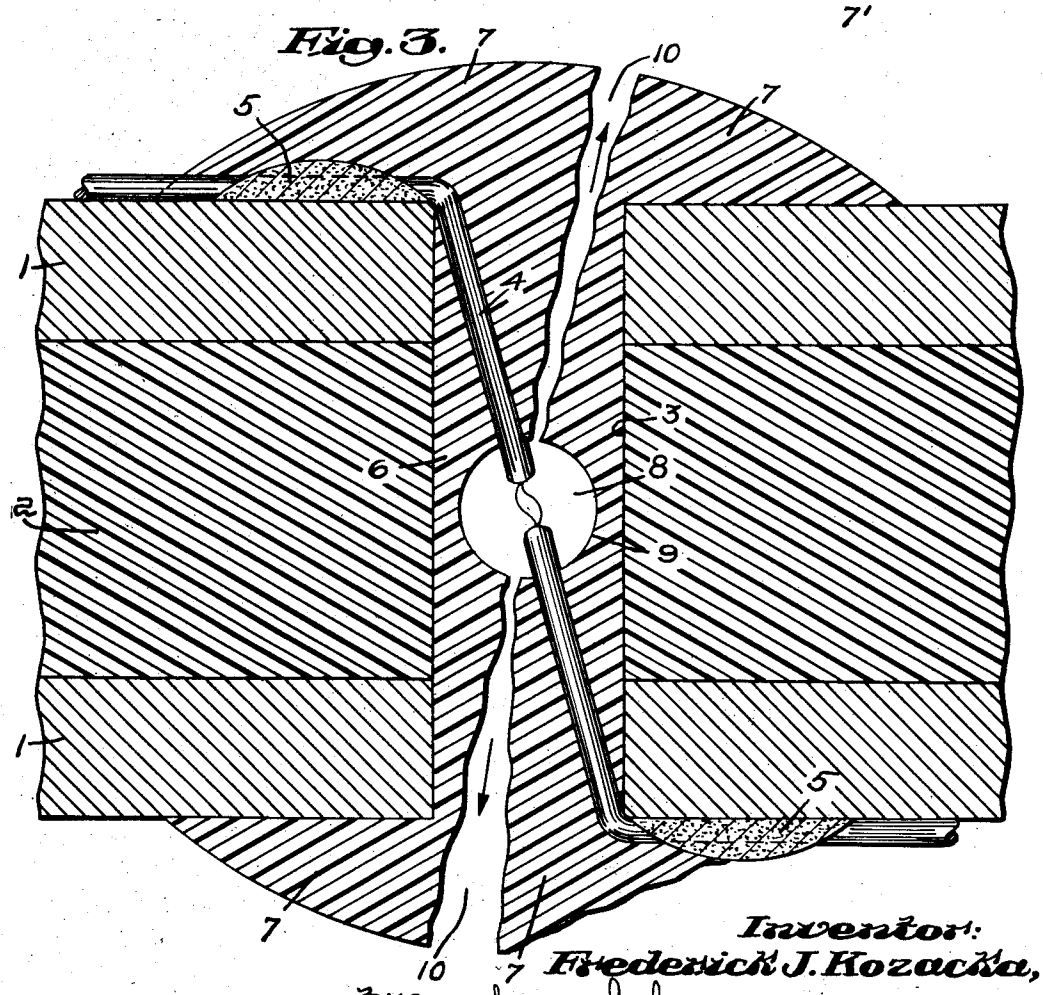


Fig. 3.



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Fig. 4.

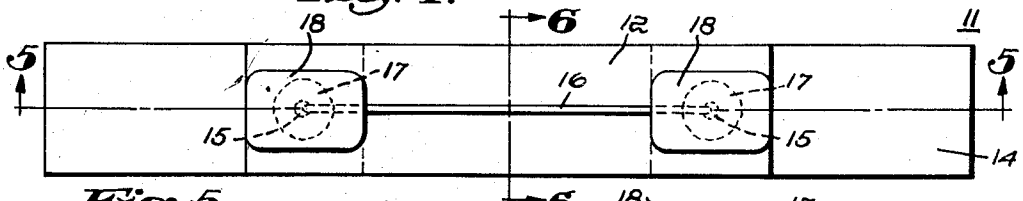


Fig. 5.

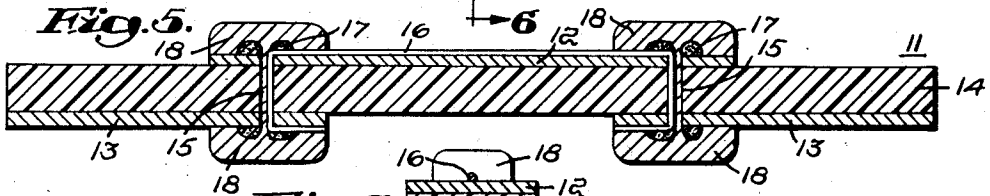


Fig. 6.

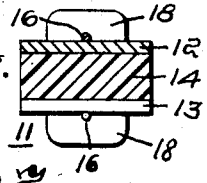


Fig. 7.

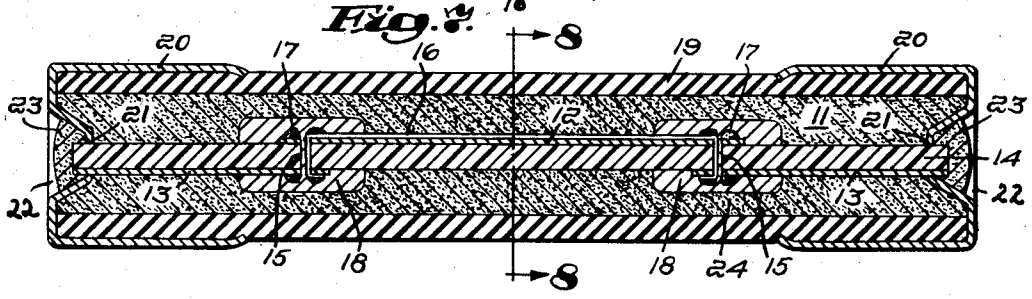
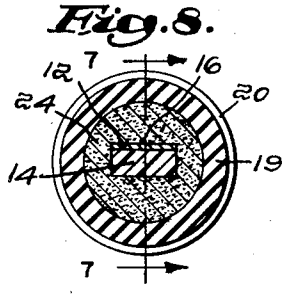


Fig. 8.



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2,895,031

FUSIBLE PROTECTIVE DEVICES

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Application July 24, 1958, Serial No. 750,618

10 Claims. (Cl. 200—120)

This application is a continuation in part of my copending patent application Ser. No. 523,832 filed July 22, 1955, now Patent No. 2,847,537, for Modular Low Impedance Fuse.

The above application is concerned with low-impedance fuses which comprise a fusible wire intended to carry current threaded through a transverse tunnel bore in a stamping of a metal-clad insulating layer formed of the kind of laminates widely used in making printed circuits.

It is one object of this invention to provide improved low-impedance fuses which embody the same principles as set forth in my above copending patent application.

Another object of my invention is to provide improved low-impedance fuses which lend themselves to the formation of any desired number of series breaks, thus being readily adaptable for various circuit voltages.

It is possible to distinguish between circuit-interrupting devices wherein the arc is drawn in a liquid and forms an arc-bubble therein by the action of which the arc is extinguished and between circuit-interrupting devices wherein a blast is caused to sweep the products of arcing away from the arc path thus cooling the latter to the point of arc extinction.

It is another object of this invention to provide fusible protective devices which do not include any normally liquid components, yet are adapted to form arc-bubbles and to take advantage of the bubble-mechanism for arc-extinction.

Still another object of this invention is to provide fusible protective devices wherein arc-extinction by bubble-action and by blast action occurs sequentially, and wherein a steep pressure gradient is caused to occur tending to expedite arc extinction.

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

Fig. 1 is in substance a longitudinal section of a structure embodying this invention drawn on a very large scale and showing the structure substantially enlarged;

Fig. 2 shows substantially in longitudinal section a modification of the structure of Fig. 1 and is drawn on the same scale as Fig. 1;

Fig. 3 is similar to Fig. 1 and illustrates diagrammatically the arc bubble formed immediately upon initiation of the interrupting process;

Fig. 4 is a top plan view of another structure embodying the invention;

Fig. 5 is a section along 5—5 of Fig. 4;

Fig. 6 is a section along 6—6 of Fig. 4;

Fig. 7 is in substance a longitudinal section of a complete fuse structure embodying the invention taken along 7—7 of Fig. 8, and

Fig. 8 is a section taken along 8—8 of Fig. 7.

Referring now to Fig. 1, numerals 1 indicate a pair of metal sheets sandwiching an insulating layer 2. Sheets 1 and layer 2 are integrated to form a structural unit. The material of which sandwich 1, 2, 1 is made is widely applied in electronics for making printed circuits. Transverse tunnel passage or bore 3 projects transversely across sheets 1 and insulating layer 2. The axis of bore 3 is at right angles to the surfaces of sheets 1. Silver wire 4 is threaded through bore 3 from the left upper edge to the right lower edge thereof. Silver wire 4 is plated with a low fusing point metal such as tin or indium to preclude any point thereof from ever exceeding for a substantial period of time the fusing point of the low fusing point metal. A solder joint 5 conductively connects the upper portion of wire 4 to the upper metal layer 1 and another solder joint 5 conductively connects the lower portion of wire 4 to the lower metal layer 1. The lower metal layer 1 is provided with a transverse groove 1*a* situated to the left of bore 3. The lower metal layer 1 is completely severed by groove 1*a*, i.e. the portion of lower layer 1 to the left of groove 1*a* is electrically insulated from the portion of that layer situated to the right of groove 1*a*. The upper metal layer 1 is provided with a similar groove (not shown) which is situated to the right of passage 3 and interrupts the current path through the upper metal layer 1. If an electric potential is applied across the laminated strip 1, 2, 1 a current path is established as follows: Upper layer 1, upper solder joint 5, wire 4, lower solder joint 5, lower layer 1. A hot spot, i.e. a spot of maximum temperature, will form in the center of the portion of wire 4 situated in tunnel passage 3. The tunnel passage 3 is filled with a normally solid thermoplastic synthetic resin liquefying and vaporizing under the heat of an arc formed upon fusion of wire 4. The plug 6 of thermoplastic synthetic resin filling tunnel passage 3 extends beyond the ends of tunnel passages 3 and forms mounds 7 on both sides of strip 1, 2, 1.

The structure of Fig. 2 comprises a laminate 1′, 2′, 1′ of the same kind as Fig. 1 having a bore 3′ of the same kind as Fig. 1. Groove 1*a*′ in the upper layer 1′ to the left of bore 3′ severs the upper layer 1′ into two portions which are electrically insulated from each other. The lower layer 1′ is provided with a similar groove (not shown) situated to the right of bore 3′. The tin- or indium plated silver wire 4′ extends from upper layer 1 through tunnel passage 3′ closely hugging the internal surface thereof to the lower layer 1′. Solder joints 5′ establish conductive connections between fusible wire 4′ and the two metal layers 1′. If an electric potential is applied across the laminated strip 1′, 2′, 1′ of which a portion is shown in Fig. 2 a current path is established as follows: lower layer 1′, lower solder joint 5′, wire 4′, upper solder joint 5′, upper layer 1′.

The structure of Fig. 3 is identical to that of Fig. 1, except for a change of proportions, and the same reference characters have been used in Figs. 3 and 1 for indicating like parts.

The operation of the structure of Figs. 1 and 3 is as follows:

As long as wire 4 carries a current within the rating of the device, or an overload current of admissible duration, the mid point of the portion of silver wire 4 inside of tunnel 3 will reach a temperature below the fusing point of the low fusing temperature plating on wire 4. Since the length of wire 4 situated inside of tunnel 4 is very short and since the cross-section of wire 4 is minimal compared to that of metal layers 1, wire 4 forms virtually a point heat source when carrying an electric current. While the length of the portion of wire 4 inside of tunnel 3 is short, this length is not negligible. A steep temperature gradient prevails between the midpoint of the portion of wire 4 inside of tunnel 3 and the points where the solder joints 5 are located. When the fusing point of the low fusing point metal with which wire 4 is plated is exceeded, the silver of wire 4 diffuses into the plating. As a result the cross-sectional area of wire 4 is reduced

causing heat generation at an increased rate and consequently a destruction of wire 4 by accelerated corrosion. An arc is kindled at the midpoint of the portion of wire 4 situated inside of tunnel 3 when corrosion has progressed to the point of forming a break. At this point of time the temperature at the point of break increases suddenly from a few hundred degrees centigrade to several thousand degrees centigrade. Therefore the thermoplastic resin surrounding the point of break is instantly liquefied and forms an arc bubble to which numeral 8 has been applied in Fig. 3. The bubble surface 9 is at the boiling point and ejects streams of relatively cool gases into the zone of the arc situated relatively close to the core thereof. The pressure in the arc bubble rises rapidly, resulting in a rapid increase of the gradient of the arc voltage of the arc burning inside of the bubble 8. It is apparent that there is no provision for the arc products inside of bubble 8 to escape. Soon the pressure inside bubble 8 is so high that the outer cool and solid portions of the thermoplastic plug 6, 7 crack or break. Reference numerals 10 have been applied to indicate two such cracks or breaks. As a result two more or less axial arc extinguishing blasts are formed by which the arc is extinguished. The high pressure gradient between the midpoint of passage 3 and the axially outer ends thereof is a factor significantly contributing to the rapid build-up of arc voltage in the structure when interrupting an electric circuit. The rapid sequence of the above described effects or phenomena is so effective in the rapid build-up of arc voltage that the action of the structure is current-limiting, i.e. when wire 4 is severed before the excess current flowing through wire 4 reaches its available peak the arc voltage rises so rapidly as to preclude any further rise of the current.

The action of the device depends to some extent upon the nature of the synthetic resin used for plugging the tunnel passage 3. Epoxy resins have successfully been used for that purpose. Inasmuch as hydrogen is a very effective arc-quencher, it is desirable to use synthetic resins for plugging passage 3 which release elemental hydrogen when being cracked under the heat of the arc. The chemistry of arc-quenching synthetic resin is sufficiently known and therefore does not need to be here considered in detail.

As a general rule carbon content is deemed undesirable in chemicals which are being used as arc quenchers, the reason being that carbon deposits tend to impair the dielectric strength of the creepage path formed across an arc interrupting gap. Carbon deposits become particularly dangerous when a number of interruptions have been performed at the same arc gap. Since the structure shown in Figs. 1 and 3 is intended to effect but one single interruption, the danger of carbon deposits is minimized. In other words, thermoplastic synthetic resins having a relatively high carbon content are not ruled out from being used as materials for plugging passage 3.

The structure of Fig. 2 operates in a fashion similar to that of Figs. 1 and 3. Because the wire 4' of Fig. 2 hugs the internal surface of bore 3', the latter evolves gases when an arc is kindled at the midpoint of the portion of wire 4' inside of tunnel passage 3'. The arc bubble is filled with gases resulting from the vaporization of the thermoplastic synthetic resin of which plug 6', 7' is made and the evolution of gas from the inner layer 2' of sandwich 1', 2', 1'. Formation of an arc bubble by liquefication of the tunnel plugging thermoplastic resin is important because the bubble effectively contains the arc products and the arc-quenching gases before permitting the escape thereof in the form of arc-quenching blasts of gas.

Referring now to Figs. 4 to 6, inclusive, numeral 11 has been applied to generally indicate a strip of metal-clad insulating material. The upper side of strip 11 supports a metal layer 12 of predetermined length situated between the ends of strip 11. The other side of

strip 11 supports a pair of metal layers 13 of predetermined length each overlapping the ends of metal layer 12 and extending away from the center of metal layer 12. Reference numeral 14 has been applied to indicate the insulating base material by which metal parts 12 and 13 are supported, parts 14, 12 and 13 forming an integral unit. Strip 11 is provided with a pair of bores 15 which project across the overlapping ends of layer 12 and layer 13. A tin or indium plated silver wire 16 is conductively connected to metal layer 12 and is threaded through bores 15. When a drop of solder is applied to a point of wire 16 immediately adjacent to one of the ends of tunnel passage 15, the solder flows around the ends of passage 15 without, however, entering into passage 15. The doughnut-shaped solder joints thus formed have been indicated by reference numerals 17. The portions of wire 16 threaded through bores 15 hug the internal surfaces thereof and their ends are bent 90 degrees and engage the ends of metal layers 13 adjacent the center of metal layer 12. The ends of wire 16 are soldered to metal layers 13 by means of doughnut-shaped solder joints 17 of the same nature as those present on the upper surface of strip 11. Tunnel passages 15 are filled with an appropriate thermoplastic resin 16, as described above more in detail in connection with Figs. 1 to 3, inclusive. The bodies of thermoplastic synthetic resin filling tunnel passages 15 and being in intimate engagement with wire 16 form mounds 18 on strip 11, i.e. projections rising above the general plane of strip 11. Mounds or projections 18 have a considerable strength and crack only when and if the pressure inside the arc bubbles formed in passages 15 has become very high.

Referring now to Figs. 7 and 8, the structure shown therein comprises a fuse tube or casing 19 of insulating material closed on both ends by terminal elements in the form of sheet metal caps 20. The inside of fuse tube or casing 19 houses a strip 11 which includes all the accessories or parts associated with strip 11 shown in Figs. 4–6 and described in connection therewith. Caps 20 are provided with apertures 21 and strip 11 projects from the inside of casing 19 through apertures 21 to the outside thereof. Each cap 20 forms a recess 22 filled with a body 23 of soft solder establishing a conductive connection between one of metal layers 13 and one of caps 20. Strip 11 is submersed in a pulverulent filler 24 arranged inside of fuse tube 19. For the purpose in hand gypsum powder is a satisfactory filler.

It will be understood that although but a few embodiments of the invention have been illustrated and described in detail, the invention is not limited thereto. It will also be understood that the structure illustrated may be modified without departing from the spirit and scope of the invention as set forth in the accompanying claims.

I claim as my invention:

1. A fusible excess-current protective device comprising a tubular casing of insulating material, a pair of terminal elements closing the ends of said casing, means conductively interconnecting said pair of terminal elements, said interconnecting means comprising a strip of metal-clad insulating material having a transverse tunnel passage, said interconnecting means further comprising a length of wire threaded through said passage, and said passage being filled by a body of a normally solid organic insulating material liquefying and vaporizing under the heat of an arc formed upon fusion of said wire.

2. A fusible excess-current protective device comprising a tubular casing of insulating material, a pair of terminal elements closing the ends of said casing, means conductively interconnecting said pair of terminal elements, said interconnecting means comprising a strip of metal-clad insulating material having a transverse tunnel passage, said interconnecting means further comprising a length of wire threaded through said passage, said passage being filled by a body of a normally solid synthetic

resin liquefying and vaporizing under the heat of an arc formed upon fusion of said wire, said casing being filled with a pulverulent inorganic substance and said strip being immersed in said substance.

3. A fusible protective device comprising a tubular casing of insulating material, a pair of terminal elements closing the ends of said casing, means for conductively interconnecting said pair of terminal elements, said interconnecting means comprising a strip of metal-clad insulating material having an insulating layer sandwiched between a pair of metal layers and defining a transverse tunnel passage, and said interconnecting means further comprising a fusible wire having a substantially U-shaped portion extending through said passage, hugging the internal surface of said passage and being conductively connected to said pair of metal layers.

4. A fusible protective device comprising a tubular casing of insulating material, a pair of terminal elements closing the ends of said casing, means for conductively interconnecting said pair of terminal elements, said interconnecting means comprising a strip of metal-clad insulating material having on one side thereof a metal layer of predetermined length situated between the ends of said strip and having on the other side thereof a pair of metal layers of predetermined length each overlapping the ends of said metal layer and extending away from the center of said metal layer, said strip having a pair of transverse bores projecting across the overlapping ends of said metal layer and of said pair of metal layers, and said interconnecting means further comprising a fusible element in wire form conductively connected to said metal layer, threaded through said pair of bores, hugging the internal surfaces of said pair of bores and engaging the ends of said pair of metal layers adjacent said center of said metal layer.

5. A fusible protective device as specified in claim 4 comprising a pulverulent filler inside of said casing submersing said strip of insulating material.

6. A fusible excess-current protective device comprising a tubular casing of insulating material, a pair of terminal elements closing the ends of said casing, means conductively interconnecting said pair of terminal elements, said interconnecting means comprising an integral strip of laminated material including an inner layer of insulating material sandwiched between a pair of outer layers of metal, said laminated material defining a plurality of spaced transverse tunnel passages, said interconnecting means further comprising fusible wire means threaded through each of said plurality of passages, each of said plurality of passages being filled by a body of normally solid synthetic insulating resin liquefying under the heat of an arc formed upon fusion of said wire, and each said body extending beyond the ends of one of said plurality of passages and forming passage-sealing mounds on the outside of said strip.

7. A fusible excess-current protective device comprising a tubular casing of insulating material, a pair of terminal elements closing the ends of said casing, means conductively interconnecting said pair of terminal elements, said interconnecting means comprising an integral strip of a laminated material including an inner layer of insulating material sandwiched between outer layers of metal, said laminated material defining a plurality of spaced transverse tunnel passages, said interconnecting means further comprising fusible wire means threaded through said plurality of passages, a plurality of bodies of a thermoplastic insulating resin each plugging one and extending beyond the ends of one of said plurality of passages, and a pulverulent filler inside of said casing, said strip being submersed in said filler.

8. A fusible protective device comprising a structure of insulating material defining a tunnel-passage, a current-carrying wire threaded through said passage, and a body of a normally solid insulating material liquefying and vaporizing under the heat of an arc formed upon fusion of said wire inside said passage in intimate engagement with said wire.

9. A fusible protective device comprising a structure of insulating material defining a tunnel passage, a current-carrying wire threaded through said passage, said passage being filled by a body of a normally solid synthetic insulating resin liquefying and vaporizing under the heat of an arc formed upon fusion of said wire, and said body extending beyond the ends of said passage and forming passage-sealing mounds on the outside of said structure.

10. A fusible protective device comprising an integral laminate formed of an insulating layer sandwiched between a pair of metal layers, said laminate defining a tunnel passage extending transversely through said insulating layer and said metal layers of said laminate, a current-carrying wire threaded through said passage and conductively connected with each end thereof to one of said pair of metal layers, and said passage being filled by a body of normally solid organic insulating material liquefying and vaporizing under the heat of an arc formed upon fusion of said wire.

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