Oct. 14, 1958 F. J. KOZACKA 2,856,488

CURRENT-LIMITING FUSES FOR SMALL CURRENT INTENSITIES

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Fig. 1.

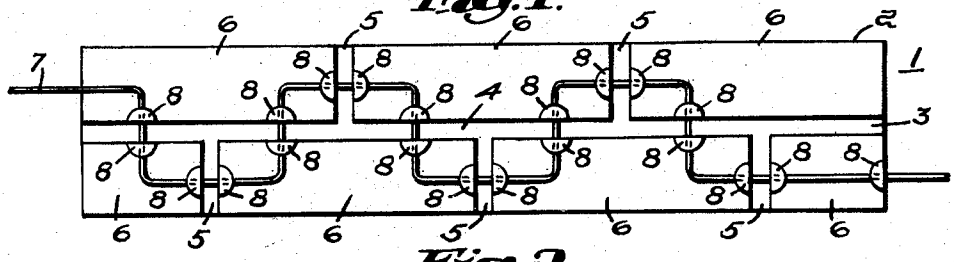


Fig. 2.

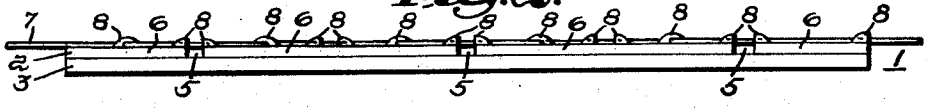


Fig. 3.

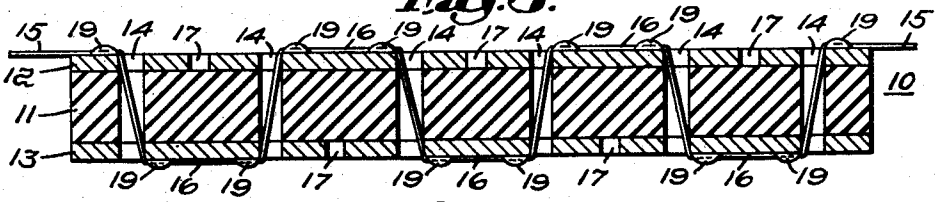


Fig. 4.

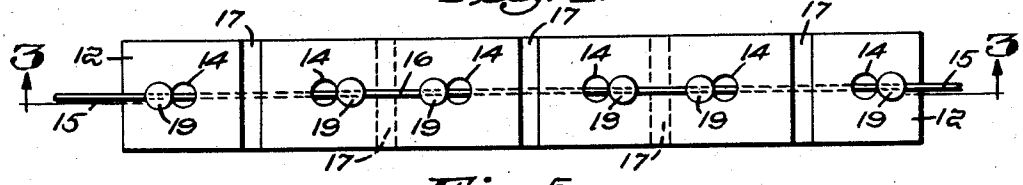


Fig. 5.

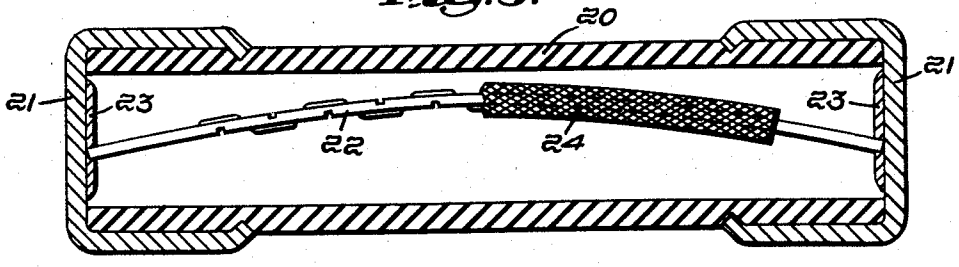


Fig. 6.

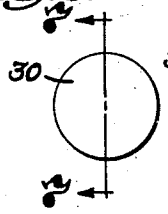
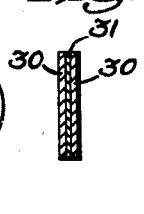


Fig. 7.



Inventor:
Frederick J. Kozacka,
by Irwin Sahn Attorney

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Fig. 8.

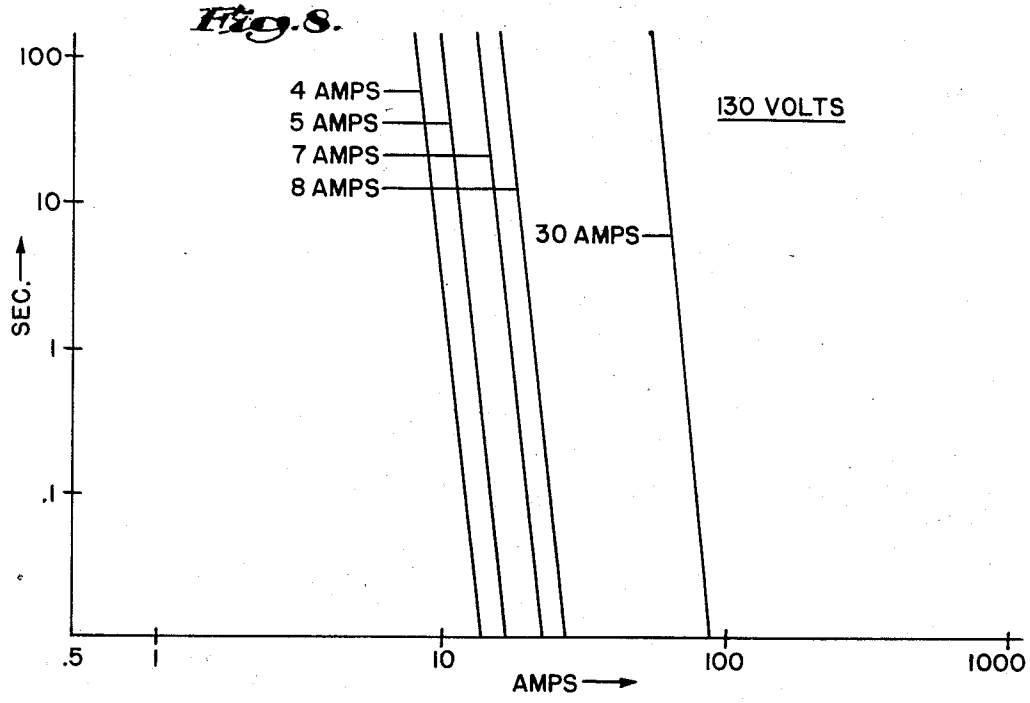
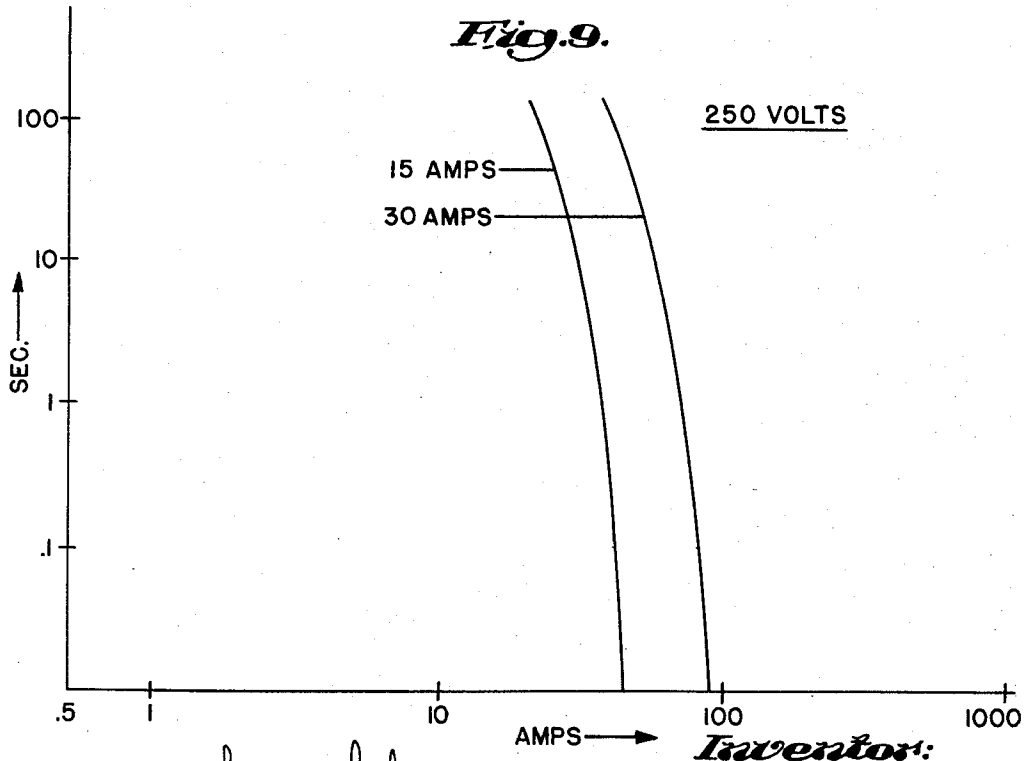


Fig. 9.



Inventor:
Frederick J. Kozacka,
By Attorney

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CURRENT-LIMITING FUSES FOR SMALL CURRENT INTENSITIES

Frederick J. Kozacka, South Hampton, N. H., assignor to The Chase-Shawmut Company, Newburyport, Mass.

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7 Claims. (Cl. 200—120)

This invention has reference to electric fuses for relatively small current intensities, and more particularly to so-called instrument fuses and fuses for protection of solid state devices as, for instance, germanium rectifiers.

It is required in many instances that a fuse blow very rapidly, once a predetermined current range is exceeded, but does not tend to blow at relatively small overload currents, even if the duration thereof is relatively long.

It is one object of this invention to provide fuses having the aforementioned operating characteristics, and more particularly fuses of this character which lend themselves particularly well to the protection of circuits normally carrying relatively small currents, i. e. currents of a few amperes, or even only of a fraction of an ampere.

The above operating characteristics may also be expressed by saying that the time-current curves of the fuses have a very steep slope.

It is, therefore, another object of the invention to provide fuses for relatively small current intensities whose time-current curves have a very steep slope.

The protection of circuits involving but relatively small current intensities calls for fuses the fusible elements of which are formed by fusible wires having a relatively small cross-sectional area. The fusing characteristics of such wires are, however, more or less incompatible with the above functional requirements, fusible wires having time-current curves which are very different from the time-current curves called for in the present instance. Relatively high circuit voltages require increasing back-burning distances, or wire lengths, and the longer the fusible wires or fuse links, the more incompatible their fusing characteristics with the above functional requirements.

It is, therefore, another object of the invention to provide fuses having relatively thin wire links capable of carrying overload currents for relatively long periods of time without fusing, but fusing very rapidly when a critical current range is exceeded, which fuses lend themselves well to interruption of low voltage circuits whose circuit voltage is relatively high, e. g. 250 volts, and more.

Another object of the invention is to provide instrument fuses whose impedance is small when carrying their rated current, which fuses are capable of generating high arc voltages on blowing, and capable of generating such arc voltages sufficiently rapidly to have a current-limiting action, i. e. to preclude short-circuit currents from ever reaching the available peak value thereof.

Another object of the invention is to provide fuses for instrument protection, dry rectifier protection, and like applications, which lend themselves well to inexpensive mass production methods.

Another object of the invention is to provide multibreak fuses wherein each of a plurality of serially related breaks is associated with a simple means for establishing an arc-generated high velocity blast of arc-extinguishing gas.

Another object of the invention is to provide multibreak fuses for relatively small current intensities wherein each point of break is capable of establishing a relatively high arc voltage.

Another object of the invention is to provide multibreak fuses combining some characteristics of fuses having relatively thin wire links, and some characteristics of fuses having relatively heavy ribbon links carrying lag blocks, i. e. relatively heavy heat-absorbing and heat-dissipating masses.

It is also an object of the invention to generally improve instrument type fuses by application of new materials not applied heretofore in the design and manufacture of fuses.

The foregoing and other general and special objects of the invention and advantages thereof will become more apparent from the ensuing particular description thereof as illustrated in the accompanying drawing, wherein:

Fig. 1 is a top plan view of a first structure embodying the invention;

Fig. 2 is a side elevation of the structure of Fig. 1;

Fig. 3 is a section along 3—3 of Fig. 4 illustrating another structure embodying the invention;

Fig 4 is a top plan view of the structure of Fig. 3;

Fig. 5 is a longitudinal section of a cartridge fuse comprising the structure shown in Figs. 3 and 4;

Fig. 6 is a top plan view of a detail of the fuse shown in Fig. 5;

Fig. 7 is a section along 7—7 of Fig. 6;

Fig. 8 is a family of time-current curves of single break fuses embodying this invention; and

Fig. 9 is a family of time-current curves of double break fuses embodying this invention.

Referring now to the drawings, and more particularly to Figs. 1 and 2 thereof, reference character 1 has been applied to generally indicate an elongated strip formed of a stamping of an integral laminate of metal and an organic insulating material. Such laminates are widely used in the so-called printed circuit technology, and printed circuit materials are particularly suitable for carrying this invention into effect. Among printed circuit materials the most suitable for the purpose in hand ought to be selected as explained below. Strip 1 includes an insulating layer 3 and at least one metal layer 2 affixed to insulating layer 3. Metal layer 2 is severed at least at one point thereof by a groove establishing at least two spaced metal layer sections electrically insulated from each other. In the embodiment of the invention shown in Figs. 1 and 2 metal layer 1 is subdivided by one longitudinal groove 4 and by five transverse grooves 5 into seven metal layer sections 6, each electrically insulated from all the others. Reference numeral 7 has been applied to indicate a fusible wire having a relatively small cross-sectional area attached to and serially interconnecting all metal layer sections 6. Wire 7 extends in a zig-zag pattern across metal sections 6, bridging the insulating gaps formed therebetween by the presence of grooves 4 and 5. Wire 7 may be affixed to metal sections 6 by drops of solder indicated at 8. Wherever wire 7 spans grooves 4, 5 wire 7 is situated relatively close to insulating layer 3. The points where wire 7 spans grooves 4, 5 are thermally relatively well insulated, whereas the portions of wire 7 in physical engagement with layer sections 6 are effectively cooled by conduction. As a result, the temperature at the points where wire 7 spans grooves 4, 5 will be relatively high, whereas the temperature along all points where wire 7 engages metal sections 6 will be relatively low. The current carried by wire 7 where the latter spans grooves 4, 5 tends to leave wire 7 where the latter is in physical engagement with metal sections 6 since the conductance

of the latter is considerably larger than the conductance of the portions of wire **7** by which they are engaged. The wire **7** may be silver wire or copper wire, both metals having a favorable ratio of conductivity to fusing energy, i. e. the energy required to cause fusion of a given mass of the metal. Metal sections **6** consist preferably of copper since their main function is to absorb heat and since the specific heat of copper is high. The copper parts of the fuse structure tend to oxidize which greatly increases the resistance to current flow between link sections **6** and fuse wire **7**. However, the oxidation of copper parts has no effect upon the operation of the fuse on account of solder spots **8**, providing points where the resistance to current flow is small and where the current enters, or leaves, wire **7**. On occurrence of excessive currents wire **7** fuses at the points where wire **7** spans grooves **4**, **5**, resulting in the initiation of series arcs at these points. Since series breaks are formed substantially simultaneously at a plurality of points, the aggregate or total arc voltage tends to be inherently high. Since the points of break are situated immediately adjacent to insulating layer **3**, the arc formed at each point of break causes evolution of gas from layer **3**, tending to de-ionize and scavenge the arc path. It is, therefore, important to use an insulating material for layer **3** capable of evolving gases tending to quench the arcs formed at the points of break and being reasonably free from tracking. There are many synthetic resins known in the art having physical properties complying with these requirements to a higher or lesser degree, and the best suitable insulating support for layer **2** may readily be selected among known materials with due regard to the specific interrupting requirements of each particular case.

It will be apparent that in the structure shown in Figs. 1 and 2 arc extinction is effected by arc-generated cross-blasts of gas. The arclets formed at the various points of break tend to move out of the path of the arc-quenching blasts of gas evolved by the insulating material, and to continue contamination of the arc gaps. Many applications suggest that the structure of Figs. 1 and 2 be translated into another similar structure having substantially the same operating characteristics but being adapted to preclude the arclets at the various points of break from more or less escaping the action of the arc-generated arc-extinguishing blasts of gas.

Figs. 3 and 4 show a structure presenting a solution to this particular problem. As a result, the structure of Figs. 3 and 4 is capable of causing the build-up of considerably higher arc voltages than the structure of Figs. 1 and 2. Referring now to Figs. 3 and 4, numeral **10** generally indicates an elongated strip comprising an inner layer **11** of insulating material sandwiched between two outer layers **12**, **13** of metal, preferably copper. Strip **10** is provided with a plurality of relatively narrow, equidistantly aligned holes **14**, each projecting transversely across the two outer layers **12**, **13** and through the inner layer **11**. A fusible wire **15** made of copper or silver and having a relatively small cross-sectional area is threaded in zig-zag fashion through all the holes **14**. Wire **15** establishes a current path in the shape of a plurality of serially related loops **16** extending substantially in a direction longitudinally of strip **10**. Layers **12** and **13** are provided with a plurality of transverse grooves **17** totally severing layers **12** and **13** at a plurality of points, thereby precluding shunting, or short-circuiting, of loops **16** by layers **12** and **13**.

The preponderant portion of the length of wire **15** is shunted by metal layers **12**, **13**, i. e. the portions of wire **15** forming loops **16** are shunted by layers **12**, **13** wherever wire **15** is in physical engagement with layers **12**, **13**. The relatively short portions of wire **15** inside perforations **14** extending between layers **12**, **13** are not shunted and carry the entire current. Spot-solder-joints **19** between wire **15** and layers **12**, **13** minimize the resistance to current flow at the points where some of the current flows either into, or out of wire **15**.

In drawing Fig. 3 the thickness of layer **11** has been exaggerated for the sake of clarity.

Occurrence of excess currents results in fusion of the relatively short portions of wire **15** situated in the space between layers **12** and **13**. Since the ends of these short portions are effectively cooled by layers **12** and **13**, the points of arc initiation are fairly well centered midway between plates **12** and **13**. Initial gas evolution is, therefore, fairly well centered in perforations or passages **14**. A high pressure prevails in the center region of passages **14** with no back-pressure at all on the axially outer ends thereof. As a result, a pair of arc-extinguishing high velocity gas blasts is established at each point of break. The operation of this arrangement differs favorably from other structures involving fusible wires in narrow holes lacking means for establishing a steep temperature gradient along the wire section, or sections, inside a hole or holes.

The number of holes or the number of series breaks to be applied in each particular case depends among other factors upon the prevailing circuit voltage. Fuses embodying this invention having current ratings of 4, 5, 7, 8 and 30 amps. and a voltage rating up to 130 volts call for but one single point of break, whereas such fuses having a voltage rating of 250 volts call for two points of break. For higher circuit voltage ratings the number of breaks must be further increased. Fuses calling for not more than two breaks comprise but one single groove **17** extending transversely across strip **10**, severing one of the two layers **12**, **13** into two separate layer sections. Such a fuse is provided with one pair of holes **14**, and the fusible wire **15** thereof zig-zags from one of said two layer sections through one of said pair of holes to the outer layer of strip **10** opposite said two layer sections, and then back through the other of said pair of holes to the other of said two layer sections.

Fusible units as shown in Figs. 1 to 4, inclusive, ought to be made integral parts of enclosed fuses, and Fig. 5 shows how this can best be achieved. Referring now to Fig. 5, reference numeral **20** has been applied to indicate a tubular casing of insulating material closed at each end thereof by a terminal element in the shape of a metal cap **21**, the axially inner ends of which are crimped into casing **20**. A fusible unit **22**, i. e. a structure of the kind shown in Figs. 1 and 2, or in Figs. 3 and 4, is arranged inside of casing **20**. The length of strip-shaped unit **22** slightly exceeds the length of casing **20**, causing unit **22** to be engaged at the axially outer ends thereof by the inner surfaces of terminal caps **21** and to be flexed. Solder joints **23** provide a highly conductive connection between each of the two ends of unit **22** and one of the caps **21**. Solder joints **23** are established by inserting a soldering disc as shown in Figs. 6 and 7 between each of the axially outer ends of unit **22** and one of the inner surfaces of caps **21**, and thereafter applying heat, preferably by induction heating.

A sleeve **24** of woven fiber glass may be arranged on unit **22** to increase the rate of deionization of the arc gaps formed at spaced points of unit **22**. Only one half of sleeve **24** has been shown in Fig. 5 to expose unit **22**.

The soldering discs shown in Figs. 6 and 7 are made up of two outer laminations **30** of soft solder, i. e. tin, and an inner lamination **31** made of an appropriate fluxing agent such as rosin sandwiched between the two outer laminations **30**.

It will be apparent from Figs. 8 and 9 which are self-explanatory that the operational characteristics of fuses embodying my invention are entirely different from any low current carrying capacity fuses known heretofore, and also entirely different from any fuses known heretofore wherein circuit interruption is achieved by fusion of a fusible wire.

It will be understood that I have illustrated and de-

scribed herein preferred embodiments of my invention, and that various alterations may be made in the details thereof without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. An electric fuse comprising an elongated strip formed by a stamping of an integral laminate of metal and organic insulation, said strip including an insulating layer and at least one outer metal layer affixed to said insulating layer, said metal layer being severed at each of a plurality of points by one of a plurality of grooves, said plurality of grooves establishing a plurality of electrically insulated metal sections, a fusible wire having a relatively small cross-sectional area conductively attached to said plurality of metal sections and zig-zaging across said plurality of grooves to establish a series connection between said plurality of metal sections, and serially related portions of said wire being arranged sufficiently close to said insulating layer to cause evolution of gas therefrom upon fusion of said portions by excessive current flow.

2. In an electric fuse the combination of an elongated strip comprising an inner layer of insulating material sandwiched between two outer layers of metal, a groove extending transversely across said strip severing one of said two outer layers into two separate layer sections, a pair of relatively narrow holes each piercing one of said layer sections, said inner layer and one of said two outer layers opposite said layer sections, and a fusible wire having a relatively small cross-sectional area zig-zagging from one of said two layer sections through one of said pair of holes to said one of said two outer layers opposite said layer sections and back through the other of said pair of holes to the other of said two layer sections.

3. In an electric fuse the combination of an elongated strip comprising an inner layer of insulating material sandwiched between two outer layers of metal, a plurality of relatively narrow holes each piercing said two outer layers and said inner layer, a fusible wire having a relatively small cross-sectional area threaded in zig-zag fashion through said plurality of holes and establishing a current path in the shape of a plurality of serially related loops extending substantially in a direction longitudinally of said strip, and a plurality of grooves extending transversely across said two outer layers totally severing said two outer layers at a plurality of points, thereby precluding short-circuiting of said plurality of loops by said two outer layers.

4. In an electric fuse the combination of a tubular casing of insulating material, a pair of terminal elements closing the ends of said casing, a resilient strip of an integral laminate comprising at least one metal layer and an insulating layer arranged inside said casing, the length of said strip exceeding the length of said casing causing said strip to engage with the axially outer ends thereof the inner surfaces of said pair of terminal elements and to be flexed, and a fusible wire supported by said strip, the preponderant portion of the length of said wire being shunted by said metal layer, and said wire including a relatively short not metal-layer-shunted length arranged immediately adjacent to a bare point of said insulating layer.

5. In an electric fuse the combination of a tubular casing of insulating material, a pair of terminal elements closing the ends of said casing, a resilient strip of an integral laminate of metal and insulation arranged inside said casing, said strip comprising an inner layer of insulating material sandwiched between two outer layers of metal, the length of said strip exceeding the spacing between the axially inner surfaces of said terminal elements to cause said strip to engage said axially inner surfaces and to be flexed, a relatively narrow hole extending at right angles across said two layers of metal and said layer of insulating material, and a fusible wire threaded through said hole and conductively connected with each end thereof to one of said two layers.

6. In an electric fuse the combination of a tubular casing of insulating material, a pair of terminal caps closing the ends of said casing, a resilient strip of an integral laminate comprising an inner layer of insulating material sandwiched between two outer layers of metal, said strip being arranged inside said casing and the length of said strip exceeding the length of said casing causing said strip to be engaged at the axially outer ends thereof by the inner surfaces of said pair of caps and to be flexed, a pair of solder joints conductively interconnecting said axially outer ends of said strip and said inner surfaces of said pair of caps, a groove extending transversely across said strip severing one of said two outer layers into two separate layer sections, a pair of relatively narrow spaced holes each piercing one of said layer sections, said inner layer and the one of said outer layers opposite said layer sections, and a fusible wire having a relatively small cross-sectional area zig-zagging from one of said layer sections through one of said pair of holes to said one of said two outer layers opposite said layer sections and back through the other of said pair of holes to the other of said layer sections.

7. In an electric fuse the combination of a tubular casing of insulating material, a pair of terminal caps closing the ends of said casing, a resilient strip of an integral laminate of metal and insulation arranged inside said casing, said strip comprising an inner layer of insulation sandwiched between two outer layers of copper, the length of said strip exceeding the length of said casing causing said strip to be engaged at the axially outer ends thereof by the inner surfaces of said pair of caps and to be flexed, a plurality of relatively narrow holes each piercing said two outer layers and said inner layer, a fusible wire having a relatively small cross-sectional area threaded in zig-zag fashion through said plurality of holes to establish a current path having the shape of a plurality of serially related loops extending substantially in a direction longitudinally of said strip, and a plurality of transverse grooves extending across said two outer layers totally severing said two outer layers at a plurality of points thereby precluding short-circuiting of said plurality of loops by said two outer layers.

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