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F. J. KOZACKA
CURRENT-LIMITING LOW IMPEDANCE FUSES FOR SMALL
CURRENT INTENSITIES
Filed Oct. 28, 1955

2,827,532

Fig. 1.

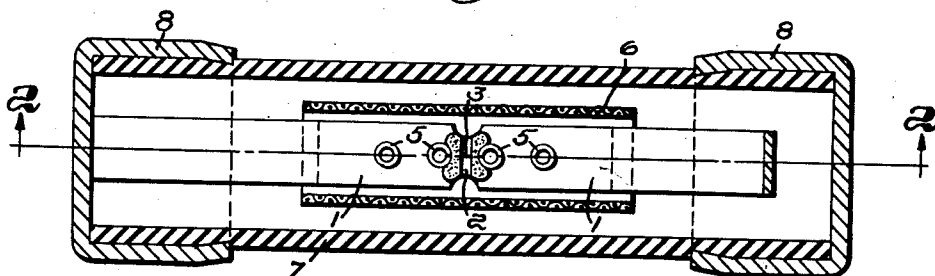


Fig. 2.

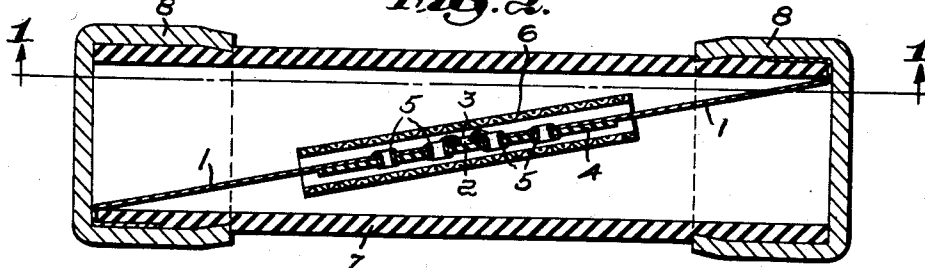


Fig. 3.

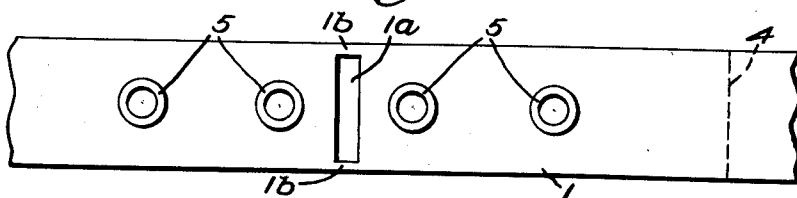


Fig. 4.

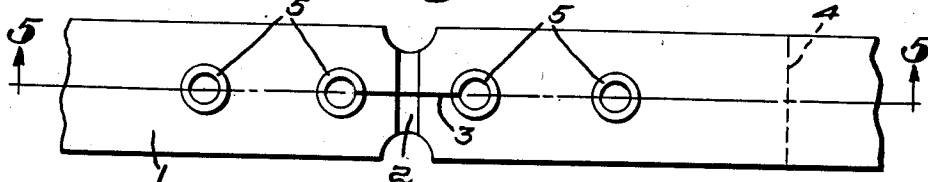


Fig. 5.

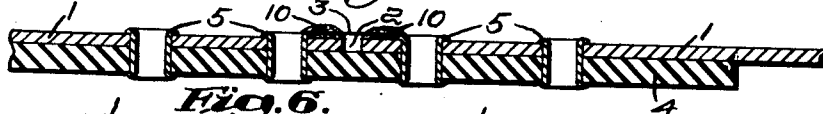
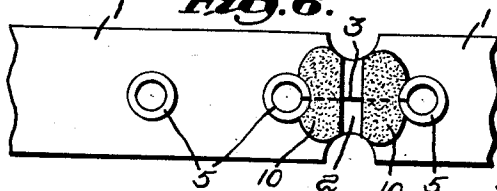


Fig. 6.



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CURRENT-LIMITING LOW IMPEDANCE FUSES FOR SMALL CURRENT INTENSITIES

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Application October 28, 1955, Serial No. 543,412

8 Claims. (Cl. 200—131)

This invention relates to current-limiting fuses, and more particularly to fuses the impedance of which is very low and which are designed for relatively small current intensities. This latter term is intended to cover the range from about 1 to about 30 amps.

It is one object of this invention to provide fuses of the aforementioned character wherein arc initiation is effected at relatively small overloads within relatively short times by the fusion of a relatively thin link wire of extremely short length. To be more specific, fusion of the link wire may occur at currents in the order of 200% to 400% of the rated current of the fuse within a time equivalent to 1 cycle of a current wave of 60 C. P. S., or even less. The diameter of the wire preferably made of silver to minimize the amount of heat required to initiate fusion of the wire may be in the order of $\frac{3}{4000}$ of an inch to minimize the heat absorbing capacity thereof and thus to shorten the pre-arcing time as much as possible. The length of the link wire may be in the order of $\frac{1}{32}$ of an inch to minimize the impedance of the fuse and the amount of heat required to initiate fusion of the link wire.

Fuses of this character are needed for the protection of critical circuit components, i. e., circuit components which are easily damaged by relatively small amounts of excess heat, i. e. heat generated beyond and above the amounts of heat normally generated therein. Such circuit components are, for example, semi-conductor rectifiers such as, for instance, germanium diodes.

It was not possible, heretofore, to manufacture fuses of the aforementioned character, i. e. such fuses have been a desideratum of protective engineers but have not been in existence as yet. It is, therefore, one object of this invention to provide fuses of the aforementioned character and to provide sub-assemblies making it possible to manufacture such fuses.

Another object of this invention is to provide basic current-limiting fuse structures having a very low impedance and a relatively small current-carrying capacity which basic structures lend themselves to cover a relatively wide range of voltage ratings by making minor changes in their arrangement.

These and other objects of the invention will become more apparent from the accompanying drawing and the following description of a preferred embodiment of the invention.

In the drawing:

Fig. 1 illustrates a fuse embodying the present invention and is a section taken along 1—1 of Fig. 2;

Fig. 2 is in substance a section taken along 2—2 of Fig. 1;

Fig. 3 is a top plan view on a larger scale than Figs. 1 and 2 of several constituent parts of the fuse shown in Figs. 1 and 2 in the process of assembly;

Fig. 4 is a top plan view of the parts shown in Fig. 3 in a more advanced stage of the manufacturing process;

Fig. 5 is a section along 5—5 of Fig. 4, and

Fig. 6 is a top plan view of the same parts as shown

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in Fig. 4 in a still more advanced stage of the manufacturing process.

Referring now to the drawing, and more particularly Figs. 1 and 2 thereof, reference numeral 1 has been applied to indicate a pair of narrowly spaced metal ribbons preferably made of copper. The fine silver wire 3 extends across the gap 2 formed between the two ribbons 1. The proper spacing between metal ribbons 1 is maintained by means of a spacing plate of insulating material 4, e. g. vulcanized fiber, to which ribbons 1 are secured by eyelets 5, or equivalent rivets. A sleeve 6 of woven glass fibers may be mounted on ribbons 1 and spacing plate 4, if it is desired to use the fuse on circuits whose circuit voltage is in excess of 65 volts, say circuits having a circuit voltage of 65 to 130 volts. Ribbons 1 are tin coated, preferably tin plated, and their axially outer ends are bent around the edges of a tubular casing 7 of insulating material as can best be seen in Fig. 2. Caps 8 of sheet metal are mounted on each end of casing 7 and crimped so as to project with their axially inner edges into the body of casing 7. The ends of ribbons 1 which are bent around the edges of casing 7 are in engagement with, and connected by soldering to, the internal surfaces of caps 8. This can be achieved by introducing the assembled fuse structure into a high frequency electric field which results in heating of caps 8 and of the axially outer ends of ribbon 1 and fusion of the layer of tin plated or otherwise coated thereon.

Wire 3 consists preferably of silver since silver combines the properties of high conductivity and low fusing $i^2 \cdot dt$. Where the requirements as to speed are less stringent the link wire 3 may be of copper which, though not as desirable as silver, still combines the properties of high conductivity and low fusing $i^2 \cdot dt$. Wire 3 is plated with a mass of link-destroying alloy-forming metal having a lower fusing point than the metal of which the link wire is made, i. e. silver or copper. The plating of the link wire is very thin. It ought to be just sufficiently thick to cause rapid link destruction by alloy-formation when the temperature of the link wire reaches the fusing point of the low fusing point metal with which the link wire 3 is plated. This minimum thickness varies with the diameter of the link wire 3. The thickness of the plating ought to be so small as to result in a fusing $i^2 \cdot dt$ of the plated wire which is considerably less than the $i^2 \cdot dt$ required for destruction, without alloy-formation, of the non-plated or the link wire 3 per se. As a general rule, the thickness of the plating ought to be less than $\frac{1}{4000}$ of an inch, provided that the diameter of the wire is of the same order. Tin is the preferred low fusing point metal to effect link-destruction by alloy-formation at a temperature well below the fusing point of the base metal of the link wire 3. Alloys of tin, for instance lead alloys of tin, may also be used to effect link-destruction. Where it is desired to reduce the fusing $i^2 \cdot dt$ as much as possible, the link wire 3 ought to be of silver and indium ought to be used as the medium for destruction of the link by metallurgical reaction. Since plating enables readily to maintain critically close tolerances, plating is by far the best method of providing the requisite link-destroying alloy-forming overlay on link wire 3; yet such overlay could also be produced by coating methods other than plating.

To achieve uniformity of operation the gap 2 between ribbons 1 must be made to close tolerances which must be maintained throughout the life of the fuse. Figs. 3 to 6, inclusive, show how this can be achieved.

Fig. 3 shows a tin-plated copper ribbon which has a punched out portion 1a extending transversely across the ribbon without, however, bisecting the ribbon into two separate portions. The left and the right end of rib-

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bon 1 are connected by bridge elements 1b maintaining the left end and the right end of ribbon 1 properly spaced. Ribbon 1 is attached to a support 4 of insulating material, e. g. vulcanized fiber, by means of four eyelets 5. The next step in the manufacturing process is removal of the bridge elements 1b or metallic spacing members between the left side of ribbon 1 and the right side of ribbon 1, thus bisecting ribbon 1 into two portions which are still properly spaced by virtue of the insulating spacer 4 but which are no longer conductively interconnected. The removal of bridge elements or metallic spacing members 1b may be effected by a punching operation, e. g. by means of a circular punch. Fig. 4 shows the ribbon and spacer structure upon removal of the bridge elements or metallic spacing elements 1b by a punch which is circular in cross-section. The next step is substitution of a thin link wire having a relatively small cross-sectional area for the two bridge elements 1b having a relatively large cross-sectional area. To this end a length of link wire or a high conductivity high fusing point metal plated with a link-destroying alloy-forming metal having a lower fusing point than the base metal is threaded through two of the eyelets 5 immediately adjacent to gap 2. Thereupon each end of link wire 3 is connected to the two separate ribbon portions 1 by two drops 10 of soft solder. As indicated in Fig. 6, these drops of solder flow irregularly toward the two eyelets 5 arranged immediately adjacent thereto, which is due to the fact that ribbons 1 get hot during the soldering operation resulting in a tendency of the liquid solder to spread. Fig. 6 shows also that the solder drops do not flow beyond the immediately adjacent or juxtaposed edges of ribbons 1, which is due to the fact that the gap between ribbons 1 is filled with an insulating material which does not get hot during the soldering operation. Thus the width of the gap 2 is not altered by soldering of link wire 3 and hence the effective length of link wire 3 is not altered. The effective length of the link wire 3 is determined by the width of gap 2, the portions of link wire 3 situated beyond gap 2 and covered by solder having no effect upon the current carrying capacity of the structure. Link wire 3 may form a slight loop tending to establish a magnetic blast action away from supporting insulating spacer 4.

The provision of woven glass fiber sleeve 6 shown in Figs. 1 and 2 on the subassembly 1, 3, 1, 4 is optional. Sleeve 6 tends to limit backburning of silver wire 3 into ribbons 1 incident to blowing of the fuse. Such a sleeve increases the interrupting capacity of the fuse and enables to increase the voltage rating thereof. A further increase in interrupting capacity and in voltage rating may be achieved by placing the subassembly 1, 3, 1, 4 into a casing of increased size.

It is important that the mass of solder drops 10 remain strictly constant for any batch of fuses. To this end droplets 10 are formed by premeasured amounts of solder, e. g. by fusing solder pellets of exactly predetermined weight.

It will be understood that the layers of link-destroying alloy-forming metal on the wire links 3 result in a derating of the wire links, i. e. a reduction of their current carrying capacity. Considering composite wire links 3 comprising an inner high fusing point core and a thin outer low fusing point envelope on the one hand, and on the other hand wire links 3 made of silver only and having the same current ratings as the above composite wire links, the links made of silver only would be of much smaller diameter, and consequently more difficult to handle, and would generate more heat than the composite links.

While, in accordance with the patent statutes, I have disclosed the specific details of an embodiment of the invention, it is to be understood that these details are merely illustrative and that many variations thereof may be made without departing from the spirit and the scope

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of the invention. It is therefore my desire that the language of the accompanying claims shall be accorded the broadest reasonable construction and shall be limited only by what is expressly stated therein and by the prior art.

I claim the following as my invention:

1. In a current-limiting fuse the combination of a casing of insulating material, a pair of terminal elements each closing one end of said casing, a strip of insulating material inside of said casing, a pair of spaced metal ribbons forming a gap therebetween, said pair of ribbons being adapted to conductively interconnect said pair of terminal elements and being arranged in abutting relation with respect to and supported by said strip, a wire link of a metal having a relatively high conductivity and a relatively low fusing $j^2 \cdot dt$ arranged in spaced relation from said strip and extending across said gap, a pair of solder joints each conductively connecting one end of said wire link to one of said pair of ribbons, and a link-destroying alloy-forming metal having a lower fusing point than the fusing point of the metal of which said wire link is made covering the portion of said wire link extending across said gap.

2. In a current-limiting fuse the combination of a substantially tubular casing, a pair of spaced metal ribbons forming a gap between the juxtaposed ends thereof housed within said casing, the axially outer ends of said pair of ribbons being turned over the edges of said casing, a pair of metal caps mounted on said casing and on said axially outer ends of said pair of ribbons and conductively connected to said pair of ribbons, an insulating spacer between said juxtaposed ends of said pair of ribbons, a wire of a highly conductive metal having a relatively small fusing $j^2 \cdot dt$ extending across said gap and conductively interconnecting said pair of ribbons, and a link-destroying alloy-forming metal having a lower fusing point than the fusing point of the metal of which said wire is made covering the portion of said wire extending across said gap.

3. In a current-limiting fuse the combination of a substantially tubular casing of insulating material, a pair of spaced conductors having a relatively large cross-sectional area forming a gap between juxtaposed ends thereof housed inside of said casing, a pair of terminal caps mounted on said casing each conductively connected to one of said pair of conductors, an insulating spacer between said juxtaposed ends of said pair of conductors maintaining said juxtaposed ends in fixed relation, a wire of silver arranged on the sides of said pair of conductors remote from said spacer extending across said gap and conductively interconnecting said pair of ribbons, and an overlay of a link-destroying alloy-forming metal having a lower fusing point than silver on said wire, said overlay being sufficiently thin to reduce the $j^2 \cdot dt$ required for metallurgical destruction of said wire below the $j^2 \cdot dt$ required for destruction of said wire without alloy formation.

4. A current-limiting fuse as specified in claim 3 wherein said overlay is plated on said wire and wherein said overlay includes tin.

5. In a current-limiting fuse the combination of a substantially tubular casing of insulating material, a pair of spaced metal ribbons housed in said casing, said pair of ribbons having a relatively large cross-sectional area and forming a gap between juxtaposed ends thereof substantially shorter than the length of said casing, a pair of terminal caps mounted on said casing each conductively connected to one of said pair of ribbons, an insulating plate extending between said juxtaposed ends of said conductors and fixedly secured thereto in abutting relation to maintain the spacing thereof, a silver wire having a relatively small cross-sectional area arranged on the sides of said pair of ribbons remote from said insulating plate extending across said gap and conductively interconnecting said pair of ribbons, a layer of link-destroying alloy-forming metal having a lower fusing point than silver

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plated on said silver wire, and a sleeve of woven fiber glass mounted on said pair of ribbons and on said silver wire to limit back-burning of said silver wire into said pair of ribbons incident to blowing of said fuse.

6. In a current-limiting fuse the combination of a pair of spaced conductors having a relatively large current carrying capacity, a wire link of a highly conductive metal having a relatively small fusing $i^2 \cdot dt$ conductively interconnecting said pair of conductors, said wire link being plated with a link-destroying alloy-forming metal having a lower fusing point than the metal of which said wire link is made, and the plating of said wire link being sufficiently thin to reduce the $i^2 \cdot dt$ required for metallurgical destruction of said wire link below the $i^2 \cdot dt$ required for destruction of said wire link without alloy formation.

7. The method of manufacturing a current-limiting fuse subassembly wherein two spaced conductors having a relatively large current-carrying capacity are conductively interconnected by a wire having a relatively small current-carrying capacity which method comprises the steps of partially severing a conductor having a relatively large current-carrying capacity, of securing an insulating spacer to the parts of said conductor partially severed to fixedly maintain the relation of said parts, and severing thereafter said parts completely without severing said spacer.

8. The method of manufacturing a current-limiting fuse

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subassembly wherein spaced metal ribbons having a relatively large current-carrying capacity are conductively interconnected by a wire having a relatively small current-carrying capacity which method comprises the steps of providing a transverse slot in a metal ribbon while maintaining the integrity of said ribbon at the edge regions situated to both sides of said slot, of affixing an insulating plate to said ribbon to fixedly maintain the spacing of the parts thereof separated by said slot, and of thereafter widening said slot to sever said ribbon into two completely separate ribbon parts.

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U. S. DEPARTMENT OF COMMERCE
PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,827,532

March 18, 1958

Frederick J. Kozacka

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 20, for "wire or" read -- wire of --.

Signed and sealed this 6th day of May 1958.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

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