

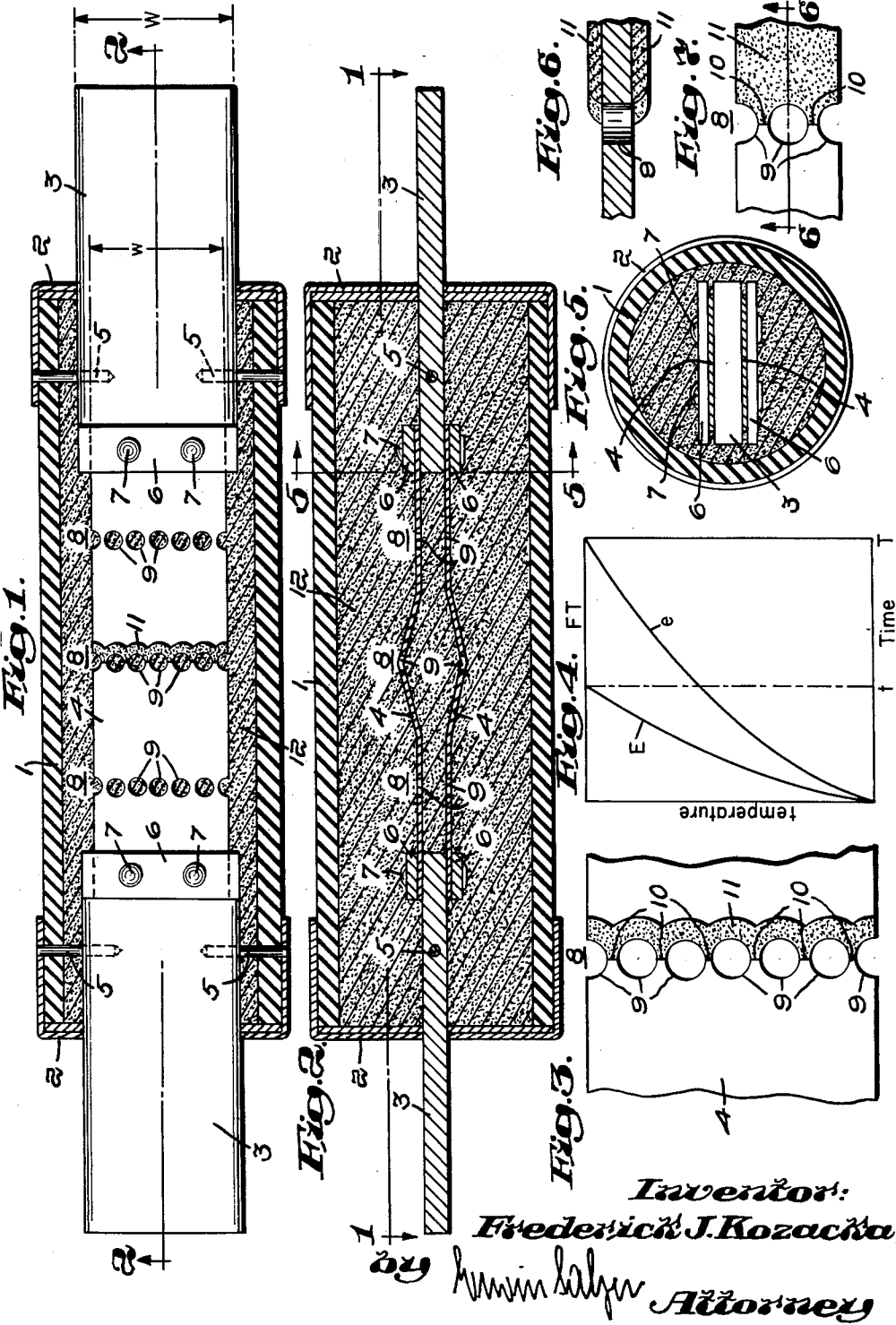
June 13, 1961

F. J. KOZACKA
TIME-LAG FUSES

2,988,620

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2 Sheets-Sheet 1



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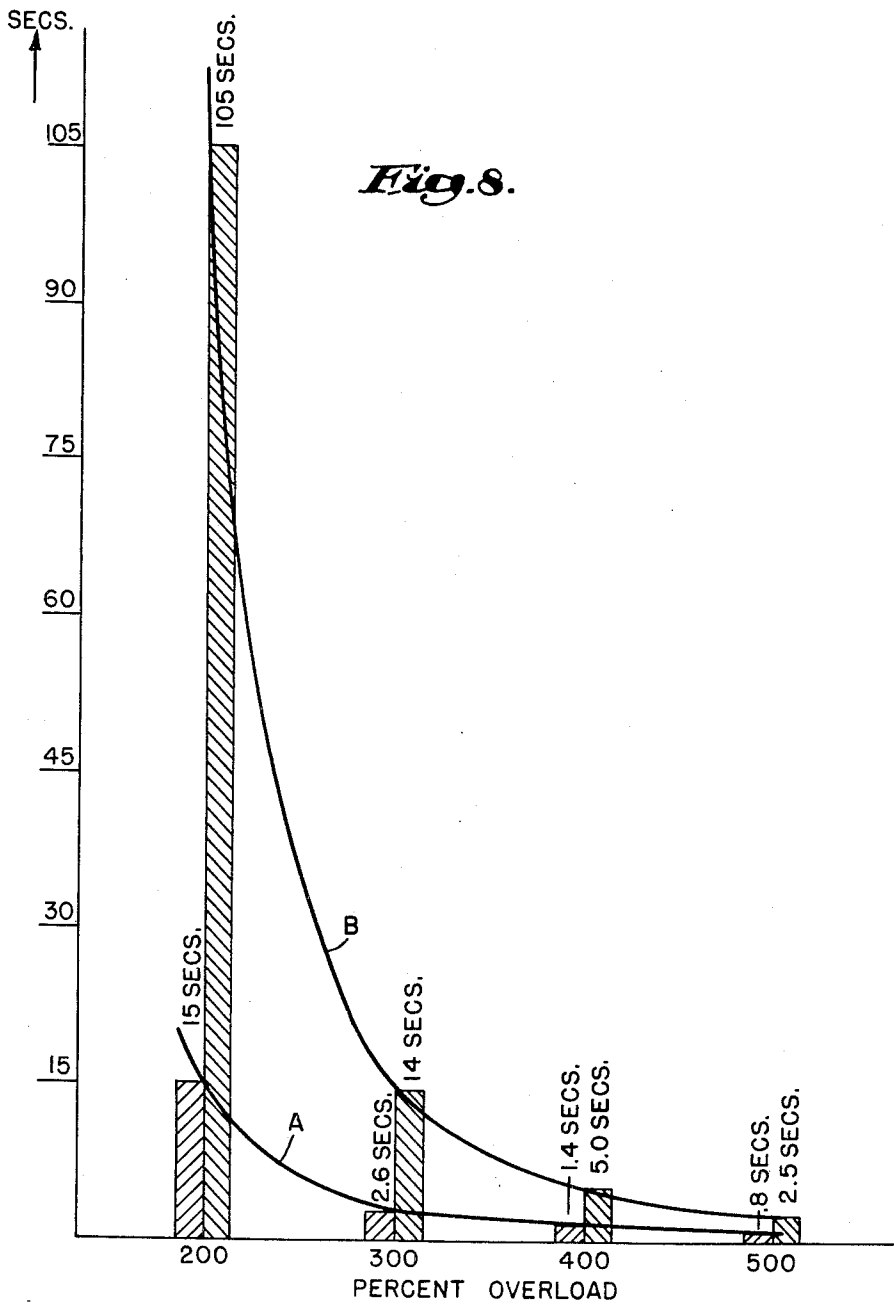
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1

2,988,620 TIME-LAG FUSES

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This invention relates to electric fuses for the protection of electric circuits against excessive current flow, and more particularly to electric fuses required to have a substantial time-lag in the overcurrent range and required to blow very rapidly in the short-circuit current range.

It is one object of this invention to provide electric fuses which have a substantial time-lag in the overcurrent range without resorting to relatively large heat-absorbing metal masses attached to the fusible element, or fuse link, frequently designated as lag-blocks.

Another object of the invention is to provide electric fuses comprising a ribbon type fuse link which has a point of reduced cross-section to cause formation of a break at the occurrence of excess currents, which point of reduced cross-section is adapted to form a break by metal corrosion relatively slowly if the excess current is relatively small and to form a break by metal corrosion relatively rapidly if the excess current is relatively large.

Another object of the invention is to provide electric fuses of the time-lag type wherein the fusible element is made of a high conductivity high fusing point metal and is provided with an overlay of a low fusing point metal which destroys the base metal of which the fusible element is made by metal corrosion when the overlay metal reaches the fusing point thereof, in which fuses fusion of the overlay metal is delayed on occurrence of relatively small overcurrents by the presence of a relatively large area of heat exchange between the base metal and the overlay metal.

A further object of the invention is to provide a mechanical connection for connecting the fusible element or fuse link into an electric circuit which connection has a minimum of ohmic resistance and therefore tends toward achieving of a cool running fuse.

Still another object of the invention is to provide novel and improved methods of manufacturing so-called dual element fuses.

Other objects and advantages of the invention will become apparent as this specification proceeds, and the features of novelty which characterize the invention will be pointed out with particularity in the appended claims forming part of this specification.

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

FIG. 1 is a longitudinal section of a fuse embodying the invention taken along 1—1 of FIG. 2;

FIG. 2 is a longitudinal section of the fuse shown in FIG. 1 taken along 2—2 of FIG. 1;

FIG. 3 shows a detail of FIG. 2 on a considerably larger scale;

FIG. 4 shows time-temperature characteristics illustrating the theory underlying the present invention;

FIG. 5 is a section taken along 5—5 of FIG. 2;

FIG. 6 is a cross-section of a modified link structure capable of achieving even longer time-lags than the structure of FIGS. 1, 2 and 3;

FIG. 7 is a top plan view of the structure shown in FIG. 6; and

FIG. 8 shows typical time-current characteristics.

Referring now to the drawings, and more particularly to FIGS. 1, 2, 3 and 5 thereof, the fuse illustrated therein comprises a casing 1 of insulating material closed on both ends by sheet metal caps 2. A pair of knife blade contacts 3 project across the general planes of caps 2 from the outside of casing 1 into the inside thereof. Knife blade contacts 3 are conductively interconnected by fusible elements 4 in the form of a pair of relatively wide copper ribbons. The width w of ribbons 4 is almost equal to the width W of blade contacts 3. Pins 5 project transversely through caps 2 and casing 1 into bores which are provided in knife blade contacts 3 and extend parallel to the general plane of contacts 3. The axially outer ends of ribbons 4 are clamped against blade contacts 3 by pressure plates 6 and clamping rivets 7. As can best be seen in FIG. 5 blade contacts 3 are sandwiched between ribbons 4 and each ribbon 4 is sandwiched between a blade contact 3 and one of pressure plate 6. Three rows 8 of circular perforations 9 project transversely across ribbon 4. Pairs of contiguous perforations form therebetween necks 10, i.e. points of greatly reduced cross sectional area where the current density is very high when the ribbon 4 carries electric currents. Reference numeral 11 has been applied to indicate an overlay on ribbon 4 made of a relatively low fusing point metal capable, upon fusion thereof, of destroying the base metal of ribbon 4 by corrosion. The base metal 4 is a high conductivity high fusing point metal such as copper or silver, and the overlay metal may be tin, an alloy of tin, indium, an alloy of indium, etc. In the case of a silver ribbon 4 an overlay of indium, or an alloy of indium, may be used. Where the base metal is copper the overlay is preferably of tin, or an appropriate alloy of tin. In the embodiment of the invention shown in FIGS. 1 and 2 only the axially inner row 8 of perforations 9 is associated with an overlay 11 of a low fusing point metal, and the axially outer rows 8 of perforations are not associated with such an overlay.

2

Referring now more particularly to FIG. 3 which shows the row of perforations 8 associated with an overlay 11 of a low fusing point metal, it will be apparent that the overlay extends from the right side of row 8 exactly to the middle of necks 10 but not beyond necks 10. This fact is of considerable importance because the intended mode of operation of the fuse depends upon it as will become more apparent as this specification proceeds. In order to obtain the aforementioned precise distribution or geometry of the overlay 11 the portion of ribbon 4 to the right of the middle row 8 of perforations 9 is heated. As a result the temperature to the right of middle row 8 is high but the temperature to the left of middle row 8 remains relatively low since necks 10 operate as heat dams. In other words, to the left of necks 10 heat dissipation is so intense as to result in a very steep temperature gradient at the necks 10. To the right of necks 10 the temperature is so high that tin or another low fusing point metal used instead of tin to form the overlay 11 is in fluid state. Slightly to the left of necks 10 the temperature of necks 10 is below the fusing point of tin, or its equivalent base metal corroding agent, and therefore overlay-formation stops abruptly at the points of steep temperature gradient which are identical with the points 10 of minimum cross-section of link 4. When link 4 is completed the entire link is submersed in a pulverulent arc-quenching filler, e.g. gypsum powder, to quench the arcs formed at the points of break 10 when the fuse blows.

At relatively low but protracted overloads initial link destruction occurs only at the middle row 8 of perforations 9, and arc extinction is effected by back-burning from that row of perforations. Link destruction under the action of relatively small protracted overloads involves substantial time-lags. At relatively high excess currents link destruction is initiated at the two axially outer rows 8 of perforations 9 and is rapidly followed by link destruction at the middle row 8 of perforations 9, thus forming a third series break. It is apparent from the foregoing that the middle row 8 of perforations 9 forms circuit interrupting breaks both at the occurrence of relatively small protracted overloads and at the occurrence of relatively high excess currents in the nature of

short-circuit currents. There is a shift of the point of initial link destruction when the hottest point of overlay 11 reaches the fusing point of the low fusing point metal at the same time as the point or points of narrowest cross-section of the link which are not associated with a corrosive overlay reach the fusing point of the base metal. In other words, there is a critical excess current which, when exceeded, results in shifting of the point of initial link destruction from the hottest point of link 4 associated with overlay 11 to the point or points of narrowest cross-section of link 4 not associated with a corrosive overlay.

The longer it takes necks 10 which are associated with overlay 11 to reach the fusing temperature of the low fusing point metal of which overlay 11 consists, the greater the time-delay of the particular fuse. The rate of increase of temperature at the necks 10 is greatly reduced by the large area of heat exchange between the overlay metal and the base metal. In other words, since the overlay metal starts at necks 10 and is spread across the entire width of the fuse link, and since the fuse link is approximately as wide as the blade contacts 3, the abstraction of heat from the necks or points of reduced cross-section 10 is highly effective, and thus delays the time required by a given overload current to heat the overlay metal to its fusing point. If the overlay metal were more concentrated, or lumped, the surface of heat exchange with the base metal of link 4 would be relatively smaller, and the heat flow away from necks 10 relatively less. Hence the times required for necks 10 to reach the fusing point of the overlay metal would be relatively longer.

It is thus apparent that the time-delays which can be achieved with a structure of the above character are due predominantly to the presence of a large area of heat-exchange between the fuse link proper and the low fusing point overlay thereon rather than to the presence of a relatively large heat absorbing mass of metal on the fuse link.

In FIG. 4 the temperature at a point of a fuse link covered by a corrosive overlay of a low fusing point metal has been plotted against time, assuming the link to be heated by a relatively small but excessive overload current. FT is the fusing temperature of the low fusing point metal at which corrosion of the base metal becomes significant. If the heat abstraction from a neck which is covered by the overlay is relatively small, the temperature at the neck rises relatively rapidly, as indicated by the exponential curve E, and fusion of the overlay metal takes place after a relatively short period of time t . On the other hand, if heat abstraction from a neck covered by the overlay is relatively large, the temperature at the neck rises relatively slowly, as indicated by the exponential curve e , and fusion of the overlay metal takes place after a relatively long period of time T.

The geometry of the clamping means 6, 7 for conductively securing links 4 to blade contacts 3 is an outgrowth of the nature of the fusible excess current protective means 4, 9, 11. The fusible excess current protective means call for a relatively large width W of link ribbons 4 substantially equal to that of blade contacts 3. This, in turn, results in a relatively small current-density at the area of contact between link ribbons 4 and blade contacts 3. The smallness of that current density makes it possible to dispense with solder joints and to resort to the simple clamp-type connections described and illustrated.

Where it is desired to achieve delay times in the overload range longer than those that can be achieved with the overlay 11 shown in FIGS. 1 to 3, inclusive, the link 4 may be covered on both sides with a destructive low fusing point overlay 11. This has been shown in FIGS. 6 and 7. The overlay 11 shown in these two figures is identical to the overlay 11 shown in FIGS. 1, 2 and 3 and described in connection therewith, except that

the overlay 11 shown in FIGS. 6 and 7 covers both sides rather than but one side of perforated copper ribbon 4.

In FIG. 8 reference letter A has been applied to indicate the time-current-curve of a conventional one time fuse having a zinc link in ribbon form and reference letter B has been applied to indicate the time-current-curve of a fuse embodying the invention substantially identical with the structure shown in FIGS. 1, 2, 3 and 5. Both fuses have the same voltage rating and current rating. It is apparent that the delay times in the small overload range up to and beyond 5 times current rating are considerably longer than the delay times of the prior art fuse though the fusible element of the prior art fuse involves a much larger mass than the structure of FIGS. 1, 2, 3 and 5. It was not possible heretofore to achieve delay times of the order represented by curve B of FIG. 8 without adding relatively large masses to ribbon fuse links, known as lag-blocks, which are being dispensed with in fuses embodying the present invention.

The basic part of which fuses embodying this invention are made is a relatively wide copper ribbon 4, or a ribbon of another metal combining the properties of high fusing point and high conductivity, and relatively low specific fusing energy, e.g. silver. At least one transverse line 8 of perforations 9 forming therebetween a line of points of reduced cross-section or necks 10 is being punched into ribbon 4. Then ribbon 4 is being heated across the entire width thereof but only to one side of the line of perforations 9. Heating is effected to and above the fusing temperature of the contemplated low fusing point overlay metal. While ribbon 4 is being heated at one side of perforations 9, the temperature at the other side of perforations 9 is being maintained at a relatively low level, e.g. at ambient temperature. Thereafter a pool of low fusing point metal is formed on ribbon 4 at the side thereof where heated, and coextensive with the entire width thereof. The next step consists in causing the constituent metal of the aforementioned pool to flow up to but not beyond the line of points of reduced cross-section 10. This may be achieved by tilting ribbon 4 in an appropriate way to induce the melted metal thereon to flow under the action of gravity in a direction longitudinally thereof. Finally ribbon 4 is permitted to cool down to ambient temperature, resulting in the structure illustrated in FIGS. 1, 2 and 3.

While in the preferred embodiment of the invention illustrated in FIGS. 1 and 2 the fuse link 4 is relatively wide and provided with a plurality of points of reduced cross-section, the fuse link 4 might be relatively narrow, as suggested by FIGS. 6 and 7, or even narrower than shown in these two figures. Narrowing down the width of the link is permissible where the fuse is intended to have a relatively small current-carrying capacity. In that particular instance the provision of but one single point of reduced cross-section or neck associated with an overlay of a corrosive metal having a lower fusing point than the base metal may suffice.

FIGS. 1 and 3 show the preferred geometry of my ribbon type fuse link having a transverse line 8 of circular perforations 9. As a result the cross-section of link 4 decreases progressively in a direction longitudinally thereof to a point of minimum cross-section, and increases with increasing distance from the aforementioned point of minimum cross-section progressively in a direction longitudinally of link 4. Such a progressive change in cross-section is helpful in expanding the overlay 11 when in liquid state substantially to the points of minimum cross-section but not significantly beyond the points of minimum cross-section. The aforementioned progressive change in cross-sectional area of the base metal toward a minimum and away from a minimum is, however, not a necessary requirement for putting my invention into effect.

It will be understood that the axially outer points of

5

reduced cross-section of link 4 fuse faster at the occurrence of relatively large excess currents, such as short-circuit currents, than the axially inner points of reduced cross-section cooled by overlay 11. On major faults involving a rapid rise of current the sequence of fusion of the axially outer and axially inner points of reduced cross-section is very rapid, and the heat exchange between the axially inner points of reduced cross-section and the overlay 11 of relatively little significance. Under such circumstances the axially inner points of reduced cross-section form a break or breaks while there is still arcing at the axially outer points of reduced cross-section. In other words, the axially inner break comes to the help of the axially outer breaks in generating arc voltage required for interruption of the faulted circuit. Referring more particularly to FIG. 3, it is apparent that each neck has a portion which is covered by overlay 11. To be more specific, the portion left to the point of minimum cross-section is not covered by overlay 11 and the portion to the right of the point of minimum cross-section is covered by overlay 11. The portions of the necks not covered and cooled by overlay 11 exhibit a sufficiently rapid rise in temperature when ribbon 4 is carrying short-circuit currents to form a break in series with the breaks then formed by the axially outer lines or rows 8 of perforations 9. It will be apparent that the portion of ribbon 4 immediately to the left from center where there is no overlay will exhibit a rise of temperature at the occurrence of currents in the nature of short-circuit currents which is almost as fast as the rise in temperature at the points of reduced cross-section formed by the axially outer lines or rows 8 of perforations 9. There is, of course, some cooling from the overlay 11 to the left of center, or the median plane of the fuse. Corrosion becomes significant in the median plane of the fuse or, in other words, at the left boundary line of overlay 11, when the fusing point of overlay 11 is reached by the portion of the link 4 situated to the left of the median plane, or to the left of the left boundary line of overlay 11. This explains why three breaks are formed in series at the occurrence of short-circuit currents, and why the structure of FIG. 3 can operate either extremely slowly or extremely fast, depending upon the intensity of the fault current involved. While it is generally desirable to provide points of reduced cross-section not associated with a low fusing point metal adapted to form breaks very rapidly on major faults in addition to the point or points of reduced cross-section associated with a low fusing point metal which forms breaks either slowly or rapidly, depending upon the intensity of the excess current, the first mentioned points of reduced cross-section may be omitted if the circuit voltage of the circuit to be protected is relatively low, say in the order of 250 volts, or less than 600 volts.

Since certain further changes can be made in the foregoing structures and other embodiments can be made without departing from the spirit and scope of the invention, it is intended that all matter shown in the accompanying drawings and described hereinbefore shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. A fusible protective device comprising a ribbon of copper having a predetermined width, a plurality of circular perforations extending transversely across said ribbon forming therebetween a plurality of transversely arranged points of minimal cross-section, said ribbon being provided with an overlay of a metal having a fusing point lower than the fusing point of copper and being substantially equal in width to said predetermined width of said ribbon, said overlay having a plurality of projections jutting into the gaps formed between said plurality of perforations to said plurality of points of minimal cross-section but not substantially beyond said plurality of points of minimal cross-section.

2. A fusible protective device comprising a fuse link in

6

ribbon form of a relatively high conductivity high fusing point metal, a plurality of lines of perforations extending transversely across said link each forming one transverse line of points of reduced cross-section, one of said plurality of lines of perforations being associated with an overlay of a link-destroying relatively low fusing point metal coextensive with the width of said link and projecting substantially to but not substantially beyond said line of points of reduced cross-section formed by said one of said plurality of lines of perforations.

3. A fusible protective device comprising a pair of fuse links in ribbon form made of a relatively high conductivity high fusing point metal, a line of perforations extending transversely across each of said pair of links forming a transverse line of points of reduced cross-section on each of said pair of links, said line of perforations on each of said pair of links being associated with an overlay of a link-destroying low-fusing-point metal coextensive with the width of each of said pair of links and projecting substantially to but not significantly beyond said line of points of reduced cross-section on each of said pair of links, a pair of knife blade contacts arranged at the axially outer ends of said pair of links having substantially the same width as said pair of links each sandwiched between said pair of links, and a pair of pressure plates on each end of said pair of links coextensive with the width of each of said pair of links clamping said pair of links against said pair of blade contacts.

4. A fusible protective device comprising a tubular casing of insulating material; a pair of terminal elements closing the ends of said casing; a pair of blade contacts extending in a direction longitudinally of said casing each projecting through one of said pair of terminal elements from the outside of said casing into the inside thereof; a ribbon of a metal having a relatively high conductivity and a relatively high fusing point, said ribbon having a width being approximately equal to the width of said pair of blade contacts and said ribbon conductively interconnecting the axially inner ends of said pair of blade contacts; a plurality of identical spaced parallel lines of perforations each extending transversely across said ribbon and each defining a transverse line of necks of reduced cross-section forming parallel current paths; and an overlay of a metal on said ribbon having a relatively low fusing point and extending from an area of said ribbon adjacent one of said transverse lines of necks to said line of necks but not significantly beyond said line of necks.

5. A fusible protective device as specified in claim 4 comprising a pair of ribbons arranged on opposite sides of said pair of blade contacts.

6. A fusible protective device comprising a tubular casing of insulating material; a pair of terminal elements closing the ends of said casing; a pair of blade contacts extending in a direction longitudinally of said casing each projecting through one of said pair of terminal elements from the outside of said casing into the inside thereof; a ribbon of a metal having a relatively high conductivity and a relatively high fusing point, said ribbon having a width approximately equal to the width of said pair of blade contacts and said ribbon conductively interconnecting the axially inner ends of said pair of blade contacts; said ribbon having a plurality of identical transverse perforated areas where cross-section decreases progressively in a direction longitudinally of said ribbon to a line of minimum cross-section and where cross-section increases progressively in a direction longitudinally of said ribbon with increasing distance from said line of minimum cross-section; and an overlay of a metal having a relatively low fusing point on said ribbon, said overlay extending from a region remote from said line of minimum cross-section substantially to said line of minimum cross-section but not beyond said line of minimum cross-section whereby both relatively small and relatively large excess currents are caused to have a destructive effect on said metal of

which said ribbon is made starting at said line of minimum cross-section.

7. A fusible protective device comprising a tubular casing of insulating material; a pair of terminal elements closing the ends of said casing; a pair of blade contacts extending in a direction longitudinally of said casing each projecting through one of said pair of terminal elements from the outside of said casing into the inside thereof; a ribbon of copper having a width approximately equal to the width of said pair of blade contacts conductively interconnecting the axially inner ends thereof; a plurality of identical spaced parallel lines formed of circular perforations each extending transversely across said ribbon and each defining a transverse line of minimal cross-sectional area; and a transverse overlay on said ribbon of a metal having a fusing point lower than the fusing point

of copper, said overlay being substantially equal in width to the width of said ribbon, and said overlay having a plurality of projections extending substantially in a direction longitudinally of said ribbon jutting into the spaces formed between the constituent perforations of one of said lines to the points of minimal cross-section formed by said spaces but not significantly beyond said points of minimal cross-section.

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