Feb. 28, 1939.

H. T. BUSSMANN

2,148,803

ENCLOSED FUSE

Filed Feb. 16, 1937

Fig 1

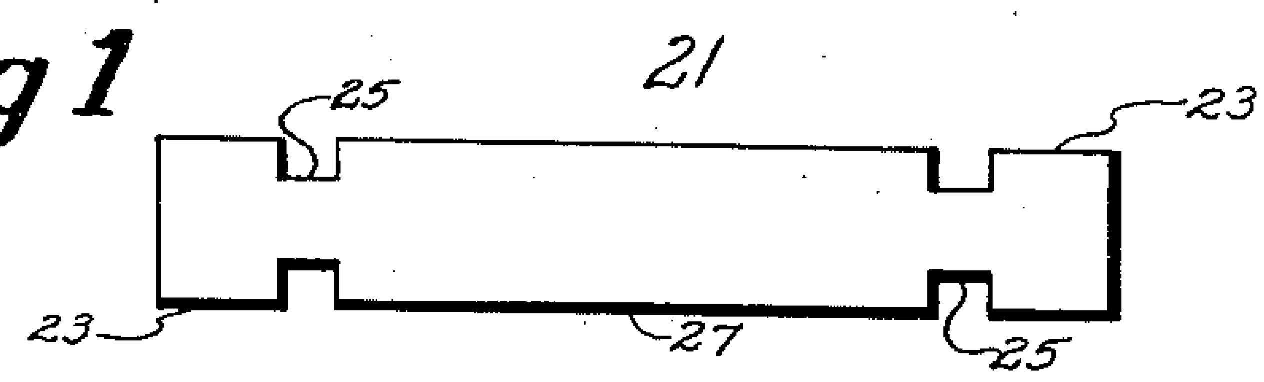


Fig 2

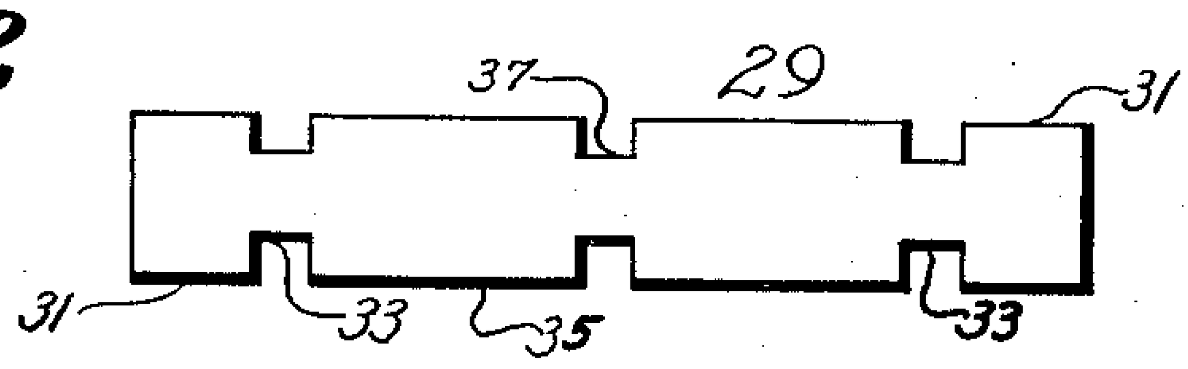


Fig 3

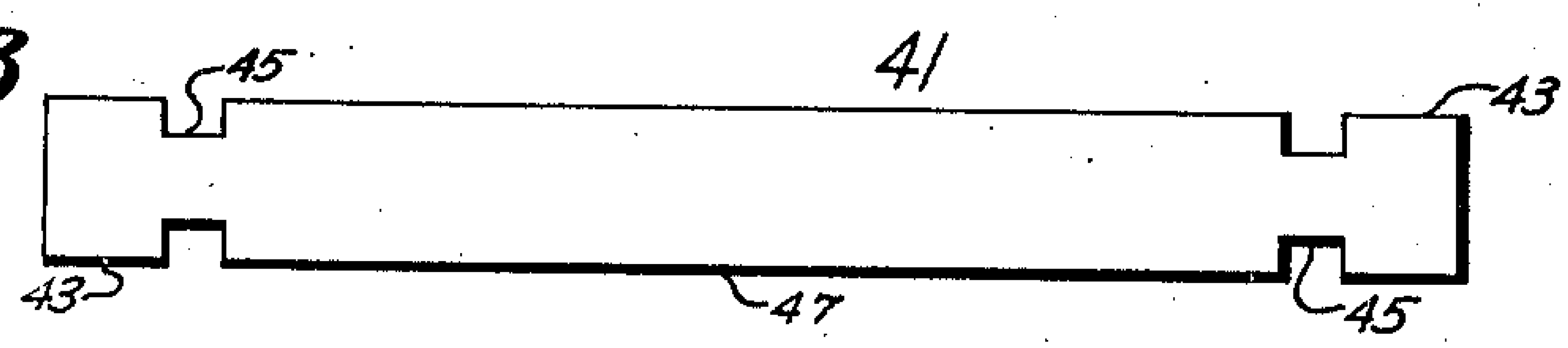


Fig 4

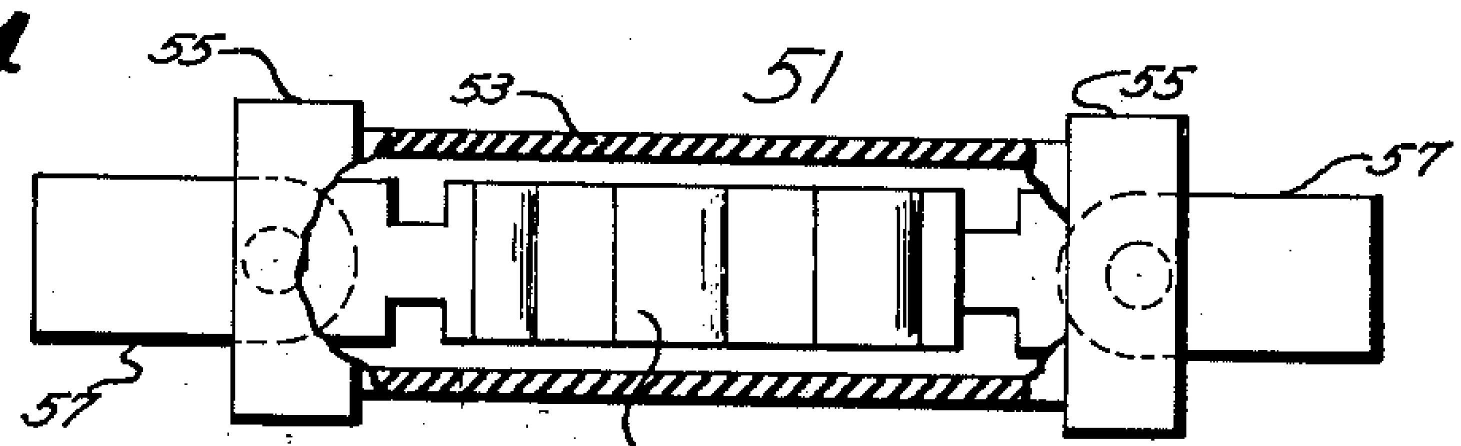


Fig 5

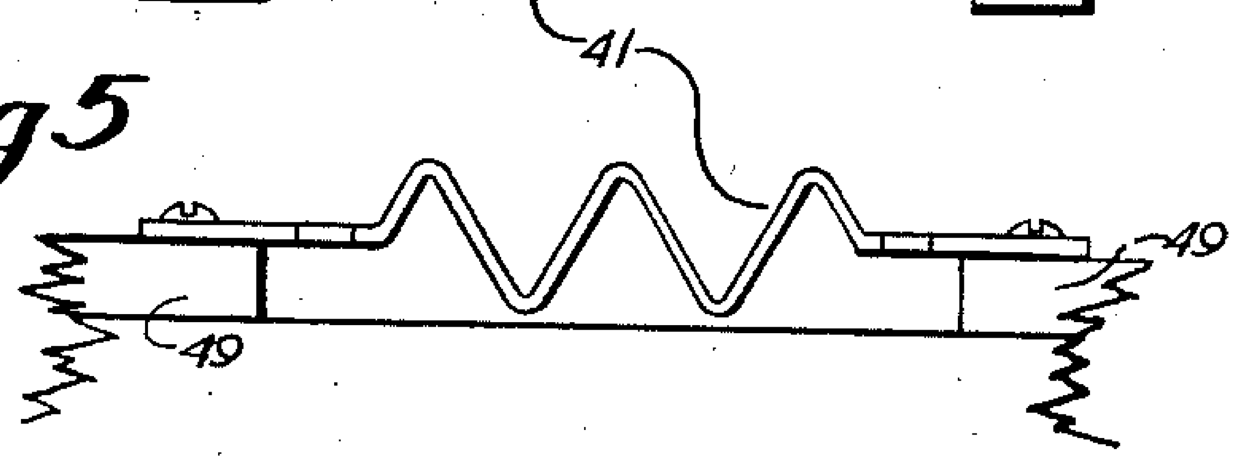


Fig 6

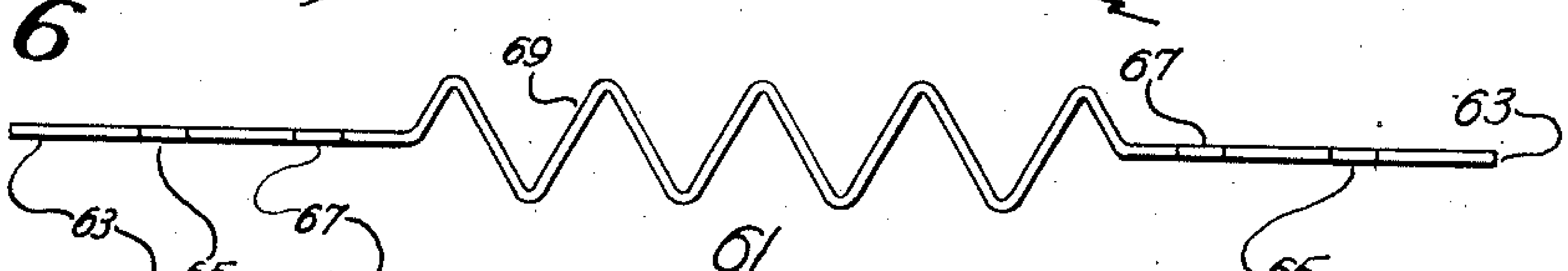


Fig 7

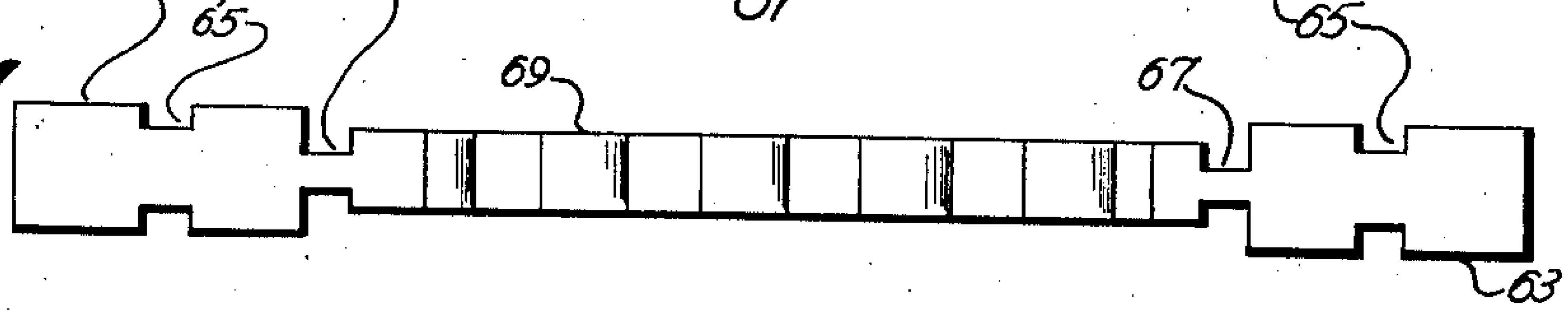
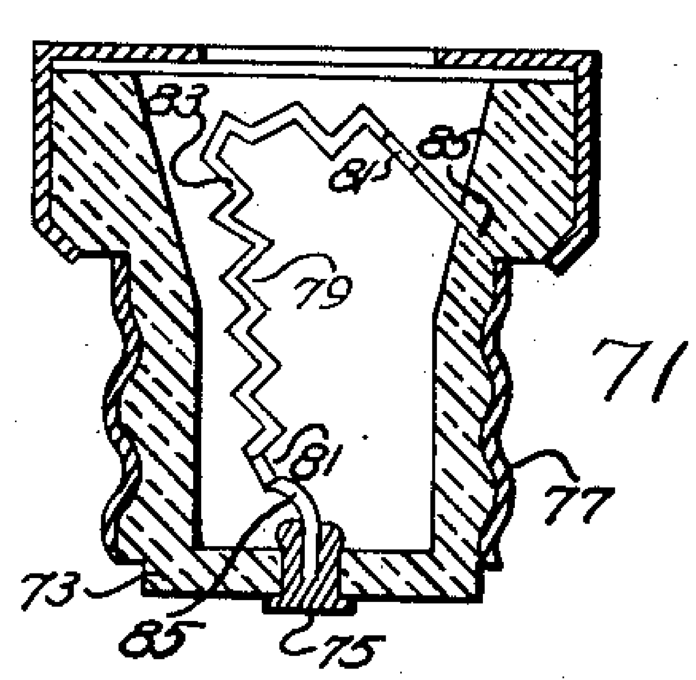


Fig 8



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Patented Feb. 28, 1939 **2,148,803**

UNITED STATES PATENT OFFICE

2,148,803

ENCLOSED FUSE

Henry T. Bussmann, St. Louis, Mo.

Application February 16, 1937, Serial No. 126,059

8 Claims. (Cl. 200—135)

My invention relates to fuses of the kind constituting part of an electric circuit and designed to protect said circuit from the effects of harmful overloads by blowing and thereby automatically interrupting the circuit.

An object of my invention is to provide a fuse that has great time lag, so as to materially reduce, or entirely eliminate, the useless blowing of fuses on harmless overloads.

Another object of my invention is to increase the time lag of an enclosed fuse while at the same time not preventing its blowing time under short circuit conditions from being substantially instantaneous or otherwise impairing its operating qualities under short circuit conditions.

A still further object of my invention is to provide an enclosed fuse of a certain rating having the above enumerated characteristics that shall have the same external dimensions as presented by standard fuses of the same rating and thereby be interchangeable with fuses of the old type on panelboards, fuse blocks and similar supporting devices.

A further and important object of my invention is to increase, by redesign of the fuse link, the time lags at ordinary overloads of enclosed fuses now in use or known to the art, while retaining acceptable short circuit characteristics according to Underwriters' Laboratories Standard for cartridge enclosed fuses.

"Time lag" of a fuse as above mentioned is the length of time the fuse takes to open the circuit at an overload expressed in percent of its maximum current carrying capacity.

Time lag must be based on the maximum current carrying capacity of the fuse to make any comparison possible. To say that two fuses each have a blowing time of 20 seconds at 100% overload would be meaningless unless the overloads are on the same basis of comparison. Otherwise one might be applied to the maximum carrying capacity of the fuse and the other might be applied to an arbitrary rating of the fuse. Ordinarily the rating of a fuse indicates merely an amount of current such fuse will carry continuously. If all fuses were rated so that such rating was directly related to the maximum carrying capacity of the fuse the rating could be used as a basis; but in actual practice it will be found that fuses will be rated at anything from 9% to 30% below their maximum carrying capacity.

In considering any portion of a current-traversed fuse link it is obvious that heat will be generated in that portion, which heat will tend to raise the temperature of that portion. Part of the heat will be lost by conduction and radiation, thereby tending to decrease the rise of temperature, the resulting temperature rise being dependent on the difference between the amount of heat generated by the passage of the current and the amount of heat lost by conduction and radiation. As the temperature rises the amount of heat lost becomes proportionately greater and a constant temperature will be attained for a given current when the amount of heat generated and the amount of heat lost become equalized. The higher the current the higher this temperature will be and if the current is sufficiently high constant temperature will not be attained before the fusing temperature of the link is reached. In this case the link blows and interrupts the current, or, in other words, the maximum current carrying capacity of the link has been exceeded.

If the link be of uniform cross-section and of the same material throughout the point which first reaches fusing temperature will be approximately midway between the ends, because, while the amount of heat generated will be the same at all points throughout, the heat lost by conduction will be greatest from near the ends where conduction can take place to the relatively cool terminals.

If the cross-section of the link be not uniform there will still be some place therein which will first reach fusing temperature, though this is not necessarily the place of least cross-sectional area, because though the heat generated at the place of least cross-sectional area will be greater per unit length, the loss of heat from there may also be greater and as a consequence the difference between heat generated and heat lost may be greater at some other portion, in which case said other portion will fuse first. This portion of the link which first fuses on the minimum current which will blow the link is referred to in the specification and claims as the "fusing center".

The effect on temperature changes brought about by conduction and radiation is greater for smaller current values since the time involved is longer. If I use a fuse link having a weak spot, such as a short portion of reduced cross sectional area, near each end I find that on short circuit the link blows at the weak spots because of the very large amount of heat generated there, only a small part of which is lost. But when carrying the smallest current which will cause the link to blow it may blow at or near the midportion of the link, because of the smaller amount of heat lost from there, even though the heat generated in the blowing portion of the link by the smaller current is much less than is being generated in the weak spots. As the value of the current is increased the fusing center of the link will continue to be approximately at the midportion of the link until a current value is reached which forces the fusing into the weak spots because the temperature rise by heat generated therein is so rapid that there is not time enough for cooling to take place by conduction of heat to the terminals.

When operating at small overloads where the blowing time is relatively long, the total amount of heat conducted away from the fusing center during this time is relatively large and consequently the effect of heat conduction is greatest for the smallest overloads, that is the maximum effect of heat conduction will be when the link is subjected to a current just large enough to blow the link. In other words the maximum current carrying capacity of a link is very largely dependent on the rate at which heat is conducted away from the fusing center. At the higher overloads however, where the time is too short for any great amount of heat to be lost as explained above, the main factor which determines the blowing time of the link is the amount of heat generated at the blowing point in this time, which heat is dependent on the cross sectional area at that point.

For the purpose of this specification a short circuit is intended to mean an extremely heavy overload, one at which the fuse should open the circuit as quickly as possible, and overloads of lesser intensity, where it is desirable to delay the operation of the fuse for a longer or shorter period, but still have it blow before such overload can continue long enough to become harmful, are referred to merely as overloads.

In the single sheet of drawings,

Figure 1 is a top plan view of a fuse link such as heretofore used,

Fig. 2 is a top plan view of a fuse link such as heretofore used and having a weak spot at the middle of its length,

Fig. 3 is a top plan view of a fuse link modified in accordance with my invention,

Fig. 4 is a view in side elevation of a cartridge fuse containing a fuse link embodying my invention, a part of the casing being cut away,

Fig. 5 is a view, in side elevation, of the fuse link of Fig. 4 to show its form, it is here shown as an open link,

Fig. 6 is a view, in side elevation, of another form of fuse link embodying my invention,

Fig. 7 is a top plan view of the link shown in Fig. 6, and

Fig. 8 is a cross sectional view of plug fuse having a link embodying my invention.

Referring first to Fig. 1, I have there shown a fuse link **21** of the kind used heretofore, in the shape of a flat strip of a fusible metal or alloy of a certain thickness and comprising two end portions **23** of a certain relatively large cross-sectional area, two weak spots **25**, each adjacent to and connected with one of the end portions, and a relatively long intermediate portion **27**.

A fuse link of the kind shown in Fig. 1 will usually blow at substantially its mid-point if subjected long enough to a moderate overload current and will blow at the weak spots if subjected to short circuit, and will have approved short circuit characteristics.

Fig. 2 shows a modification of the fuse link shown in Fig. 1, in which a link **29** is provided with end portions **31** of relatively large cross-sectional area, two weak spots **33** adjacent the end portions, and an intermediate relatively long portion **35**, which has a weak spot **37** therein at substantially the middle of its length, all other dimensions being the same as in Fig. 1. The use of the third weak spot **37** is suggested by the possibility of a more accurate control of the continuous current rating of such links in mass manufacture or for better performance on short circuit on higher voltages. It is obvious that the continuous current rating of fuse link **29** is less than that of fuse link **21**, this reduction in current rating being caused by the third weak spot **37**.

Fig. 3 shows one form of fuse strip **41** embodying my invention and comprising end portions **43** of relatively large cross-sectional area, a pair of relatively short portions **45** of reduced cross-sectional area and an intermediate portion **47** of relatively large cross-sectional area and having a length greater than that of the intermediate portion of the links shown in Figs. 1 and 2. The thickness of this link, for the same carrying capacity, is substantially greater than the thickness of that shown in Fig. 1, and the length of the end portions and of the weak spots may be the same as of like parts in the fuse links of Figs. 1 and 2. It is to be noted that the length of the intermediate portion **47** is greater than that of either end portion. It may be here pointed out that parts of the lengths of the end portions will be attached to respective terminals and will not constitute effective parts of the end portions when the link is mounted in an enclosing casing.

Fig. 4 shows a link of the kind illustrated in Fig. 3 as contained in a standard casing **51** of the cartridge type. The casing includes a tubular member **53**, of electric-insulating material, ferrules **55** at the respective ends of the tube and knife blade contact terminals **57** electrically connected with the end portions of the fuse link in any desired manner. The cartridge fuse **51** may be of the present standard size for a certain rating in accordance with the National Electric Code and, since the length of the link **41** is greater than that heretofore used in fuse links of that rating, some provision must be made to take care of the increased length, which is done by bending parts of the intermediate portion out of the linear plane connecting the end portions, as will be hereinafter more clearly set forth. The tubular member may be filled with an arc quenching filler if desired.

I desire to point out that a substantial part of the increased length of the link is included in the intermediate portion of the link since I have found, as the result of numerous tests, that lengthening the end portions has only a small effect upon the time lag.

Figs. 6 and 7 illustrate another form of link **61** embodying my invention which link includes end portions **63** of relatively large cross-sectional area, a pair of outer weak spots **65**, a second pair of weak spots **67** spaced a small distance away from and inside the outer weak spots and an intermediate portion **69** whose cross-sectional area is somewhat less than that of the end portions **63** and of the parts between two adjacent weak spots at the respective ends. Those parts of the link between adjacent weak spots **65** and **67** at the respective ends of the link are to be considered as parts of the intermediate portion **69**. The intermediate portion has been so formed with a series of bends that the link can be contained in a casing of the cartridge type of a size which is standard for that particular current rating in accordance with the National Electric Code. A fuse link of the type shown in Figs. 6 and 7 is particularly adapted for high voltage circuits and the reduction in the cross-sectional area of the intermediate portion over the end portions is dictated by other considerations than those pertaining to my present invention.

Fig. 8 illustrates a fuse plug assembly 71, comprising a hollow plug body 73, of electric-insulating material, having a central contact terminal 75 at one end and a screw shell contact terminal 77 around the body. A fuse link 79, embodying my invention, is contained in the hollow body. This link has a pair of weak spots 81 near the ends of the link, a relatively long intermediate portion 83 and outer end portions 85 connected to the respective terminals in any suitable manner. This form of my invention distinguishes from fuse plugs now in use and not embodying my invention, in that the fuse link embodies weak spots near the ends thereof and in that the length of the intermediate portion is greater than that of either end portion and greater than would normally be used in a fuse not embodying my invention and of the same current rating.

The device embodying my invention is based upon the following: The length of blowing time of a fuse link under ordinary overload conditions is increased by increasing the cross-sectional area of the fusing center, and while I may increase the cross-sectional area of only the mid-portion of the link, or of the intermediate portion or of the entire length of the link, I find it easier in commercial mass production to thicken the fuse strip over its entire length. This of course increases the continuous current rating of the fuse link, which is then reduced by reducing the heat conductivity from the mid-point of the link to its ends. This may be done in several different ways, as by using different material for different parts of the link, but this might also reduce the electrical conductivity and cause more heat to be generated, or by narrowing the fuse link at other than its mid-portion, which would indeed lower the rating but would also decrease the blowing time for the same reason as given above, or by the method which I use, namely, to increase the length of the intermediate portion, which produces the desired result as to decreased heat conductivity from the mid-portion of the link without introducing other extraneous disturbing factors.

The following table gives results of tests on fuse links embodying my invention, the figures in the first line of each set of figures being those for a fuse link not embodying my invention, and of the design shown in Fig. 1 of the drawing. The length of each of the end portions was .533", the length of each of the weak spots was .130" and the width of the strip was .375".

Thickness	Length of portion 47	Maximum current carrying capacity	Blowing time at 2½ times M. C. C. C.
Inches	*Inches*	*Amperes*	*Seconds*
.012	1.674	60.0	8.1
.0135	1.674	53.5	9.4
.0135	1.974	59.0	12.8
.0135	2.274	55.0	18.0
.0135	2.874	49.0	31.0
.012	1.674	60.0	8.1
.0145	1.674	66.5	12.4
.0145	1.974	61.6	14.2
.0145	2.274	59.0	19.2
.0145	2.874	52.0	32.0

Referring to the first set of figures, it will be noticed that an increase of the thickness from .012" to .0135" increased the time lag only a small amount while it also increased the current rating of the fuse link. An increase of 18% in the length of the intermediate portion of a strip .0135" thick resulted in an appreciable increase in the time lag, while increases of 36% and 72% in the length of the intermediate portion gave very large increases in the time lag, the time lag for the longest link being almost four times that of the short thin link. It is thus obvious that increases in the cross sectional area of a certain portion of the link or of its entire length and a simultaneous increase in the length of the intermediate portion of the link over its original value (which may or may not be the straight line distance between the weak spots) increases the time lag on overloads.

Referring to the second set of figures, the increase in the thickness was substantially 21% as compared to 12.5% in the first set. The current rating of the short thickened link was increased appreciably and this link had a somewhat greater time lag than did the short thickened link in the first set. Links having their intermediate portions increased by 18%, 36% and 72%, gave even larger time lags than was the case for the corresponding fuse links of the first set.

I find that an increase in the cross sectional area of the link at the point where it blows at a given overload increases the blowing time at such overload because of the lesser amount of heat there generated. A decrease in the heat conductivity from this point lowers the blowing time at a given current, but this effect is greater the longer the time before blowing occurs, so its effect on the maximum continuous current carrying capacity of the link is greater than its effect at any higher overload, consequently by increasing the cross sectional area at the point where blowing occurs and at the same time decreasing the heat conductivity from this point, I get a greater relative decrease of the current rating than I do of the length of blowing time at a given overload and thereby increase the time lag. The increase in time lag is greater at lower overloads than at higher overloads, which is an additional favorable condition.

While it is obvious that a slightly increased cross sectional area of the weak spots in a fuse link embodying my invention may increase slightly the blowing time on short circuit, it is to be noted that this blowing time is so nearly instantaneous and the increase is so small that it will not have any appreciable or noticeable effect on the operation of the fuse when it is subjected to and blows under a short circuit.

The method herein disclosed can be used in redesigning a fuse link and in manufacturing a fuse link to have a greater time lag than is at present obtainable with the ordinary fuses. It can be used to design and make any fuse link, but is particularly applicable to links to be mounted in fuse casings, either cartridge or plug type, whose dimensions are in accordance with the Underwriters' Laboratories Standards for enclosed fuses. For example, if a fuse link of the same general design as a given fuse link but having a greater time lag, is desired, I make a link with increased cross sectional area at the minimum current fusing portion only or over the length of the intermediate portion or over the entire length of the fuse link, to obtain the desired blowing time and with increased length of the intermediate portion only to restore the current rating to the value of that of the given link, the redesigned link being otherwise of the same general design as the given link.

Since the fuses embodying my invention are to have acceptable short circuit characteristics as well as relatively long time lags on lower overloads, I design and make them to have certain relations as to the size and current carrying capacity of the weak spots and their location with reference to each other and other characteristics of the fuse link. Thus the outer weak spots are always relatively close to the terminals, the intermediate part is always relatively long as compared to other portions of the link and this intermediate portion may, and for higher voltages usually will have, auxiliary weak spots in its length, the number, characteristics and location of which are dependent on the operating results which the link is to give.

I have shown and described the weak spots as short portions of reduced cross sectional area, as that is a relatively easy method of producing them in a nonmetallic strip, but I do not desire to be limited to such a link or to such method of producing weak spots. I may use a link comprising more than one kind of metal, the weak spots consisting of more easily fusible metal or of metal having a higher electrical resistance than other parts of the link. The weak spots are those parts of the link which fuse or blow first on very heavy currents, such as short circuits, and are "weak" in that they can carry a short circuit current without fusing for a shorter period of time than can other portions of the link and the expression "weak spot" as used in the specification and the claims is to be interpreted as having that meaning, independently of their size or shape or of the method by which they are "weakened".

The term fuse "rating" as used in the specification and the claims is to be interpreted as being directly related to the maximum current carrying capacity of the fuse.

While I have illustrated and described a fuse strip, my invention applies also to a fuse link made of a casting, or of a single wire or of a number of wires in parallel, so long as the link is designed and constructed in accordance with the principles of my invention herein set forth.

What I claim is:

1. An enclosed fuse comprising a cylindrical hollow casing, terminals adjacent the ends of the casing, a fuse link formed from a unitary strip of metal, having a weak spot adjacent each terminal, the distance along the link between weak spots being greater than the distance between a weak spot and its adjacent terminal, said link being adapted to extend from one terminal to the other terminal and having a folded portion between the weak spots of a developed length and current path in excess of the actual distance between said weak spots.

2. An enclosed fuse comprising a cylindrical hollow casing, terminals therefor, a fuse link formed from a unitary strip of metal, having a weak spot adjacent each terminal, the distance along the link between weak spots being greater than the total distance between weak spots and terminals, said link being adapted to extend from one terminal to the other terminal, and having a folded portion between the weak spots of a developed length and current path in excess of the actual distance between said weak spots.

3. An enclosed fuse comprising a cylindrical hollow casing, terminals adjacent the ends of the casing, a fuse link formed from a unitary strip of metal, having a weak spot adjacent each terminal, the distance along the link between weak spots being greater than the distance between a terminal and its adjacent weak spot, said link being adapted to extend from one terminal direct to the other terminal, and having a portion between the weak spots of a developed length and current path in excess of the actual distance between said weak spots.

4. A fuse link formed from a unitary strip of metal adapted to be mounted on the terminals of a cylindrical hollow casing, said link having a weak spot adjacent each terminal, the distance along the link between weak spots being greater than the total distance between weak spots and terminals, said link being adapted to extend from one terminal to the other terminal and having a folded portion between the weak spots of a developed length and current path in excess of the actual distance between said weak spots.

5. A fuse link formed from a unitary strip of metal adapted to be mounted on the terminals of a cylindrical hollow casing, said link having a weak spot adjacent each terminal, the distance along the link between weak spots being greater than the distance between a weak spot and its adjacent terminal, said link being adapted to extend from one terminal to the other terminal, and having a folded portion between the weak spots of a developed length and current path in excess of the actual distance between said weak spots.

6. A fuse link formed from a unitary strip of metal, adapted to be mounted upon the terminals of a cylindrical hollow casing, said link having a weak spot adjacent each terminal, the distance along the link between weak spots being greater than the distance between a terminal and its adjacent weak spot, said link being adapted to extend from one terminal direct to the other terminal, and having a portion between the weak spots of a developed length and current path in excess of the actual distance between said weak spots.

7. A fuse link adapted to be mounted on spaced terminals and formed from a unitary strip of metal, said link having weak spots so located as to be near each terminal, the distance along the link between weak spots being greater than the distance between a weak spot and the adjacent terminal, said link being adapted to extend from one terminal to the other terminal and having a folded portion between the weak spots of a developed length and current path in excess of the actual distance between such weak spots.

8. A fuse link adapted to be mounted on spaced terminals, said link having weak spots so located as to be adjacent each terminal, the distance along the link between weak spots being greater than the distance between a weak spot and the adjacent terminal spot, said link being adapted to extend from one terminal to the other terminal, and having a folded portion between the weak spots of a developed length and current path in excess of the actual distance between said weak spots, the fusing center of the link being of like melting point throughout.

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