United States Patent [19]

Kozacka

[11] **3,864,655**

[45] **Feb. 4, 1975**

[54] **ELECTRIC FUSE FOR ELEVATED CIRCUIT VOLTAGES HAVING A PLURALITY OF RIBBON FUSE LINKS CONNECTED IN PARALLEL**

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[73] Assignee: **The Chase-Shawmut Company**, Newburyport, Mass.

[22] Filed: **Mar. 4, 1974**

[21] Appl. No.: **448,074**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 250,175, May 4, 1972.

[52] **U.S. Cl.** **337/160**, 337/159, 337/296

[51] **Int. Cl.** **H01h 85/04**

[58] **Field of Search** 337/158, 159, 160, 161, 337/279, 296

[56] **References Cited**

UNITED STATES PATENTS

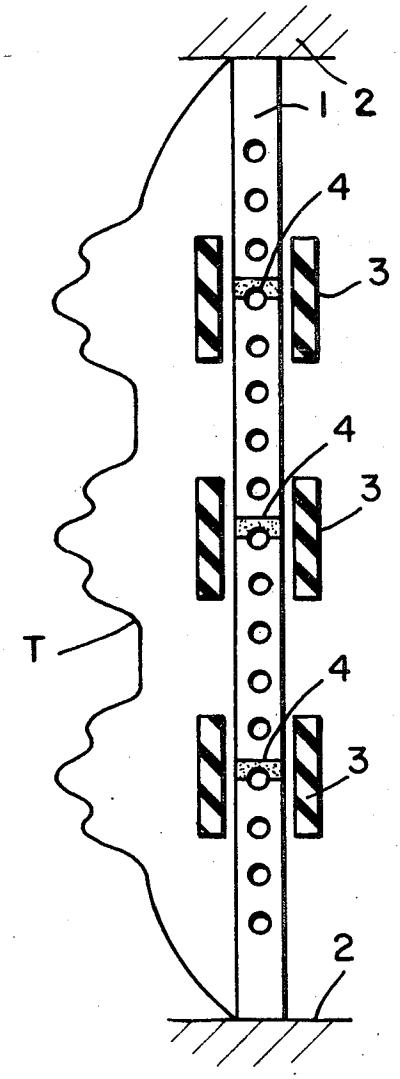
2,827,532	3/1958	Kozacka	337/160
3,287,524	11/1966	Huber et al.	337/159
3,294,937	12/1966	Kozacka	337/296

Primary Examiner—J. D. Miller
Assistant Examiner—Fred E. Bell
Attorney, Agent, or Firm—Erwin Salzer

[57] **ABSTRACT**

An electric fuse for elevated circuit voltages has a plurality of ribbon fuse links connected in parallel. The fuse is designed to have full range interrupting or clearing capacity, i.e., to be able to interrupt small currents but slightly in excess of its minimum fusing current up to the largest major fault currents that may occur in distribution systems at points close to the source of power. This is achieved mainly by mounting on each of said plurality of fuse links a plurality of pellets of a gas evolving material, each of said plurality of fuse links having a metal-severing low fusing point overlay covered by one of said plurality of pellets and each of said plurality of fuse links being threaded through and supporting pellets of a gas evolving material which are positioned at points where there is no metal-severing low fusing point overlay.

6 Claims, 6 Drawing Figures



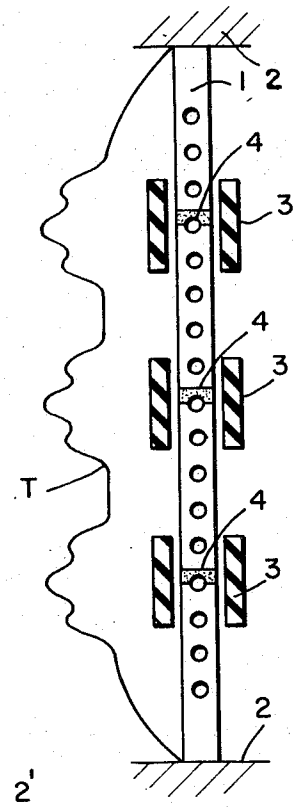


FIG. 1

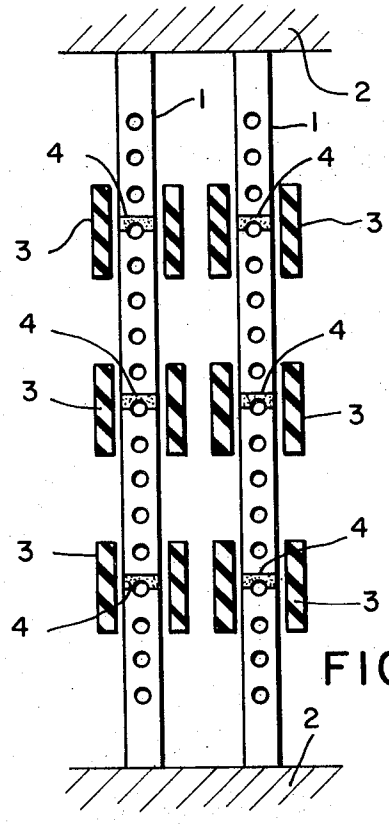


FIG. 2

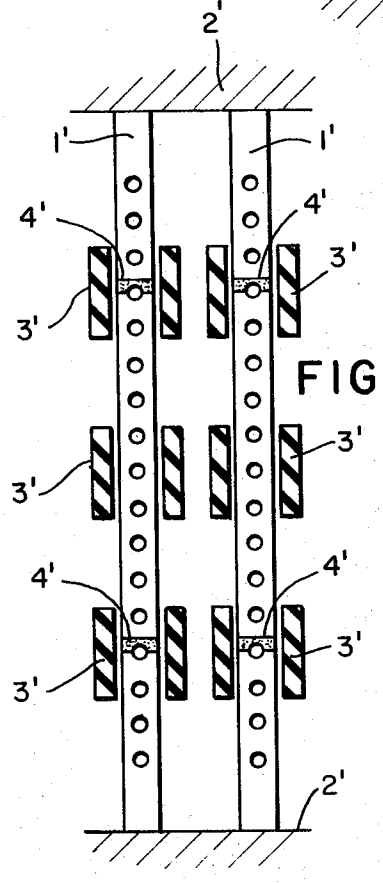


FIG. 3

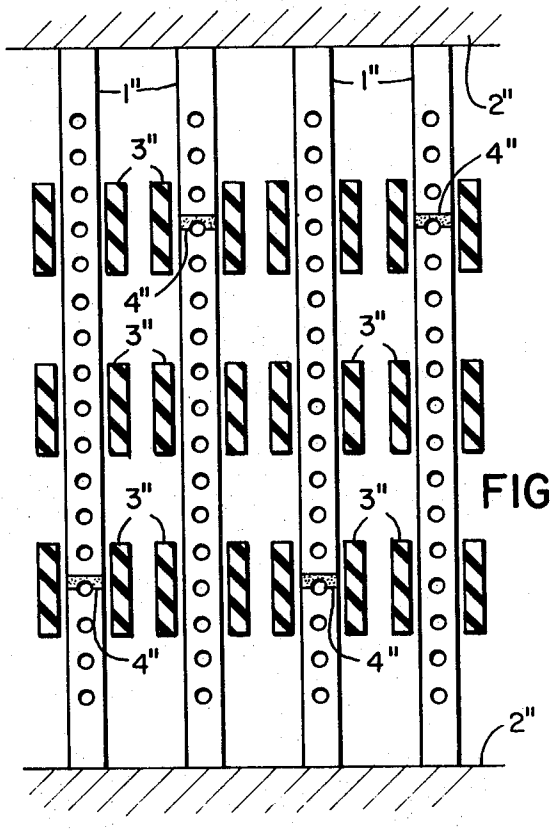


FIG. 4

FIG. 5

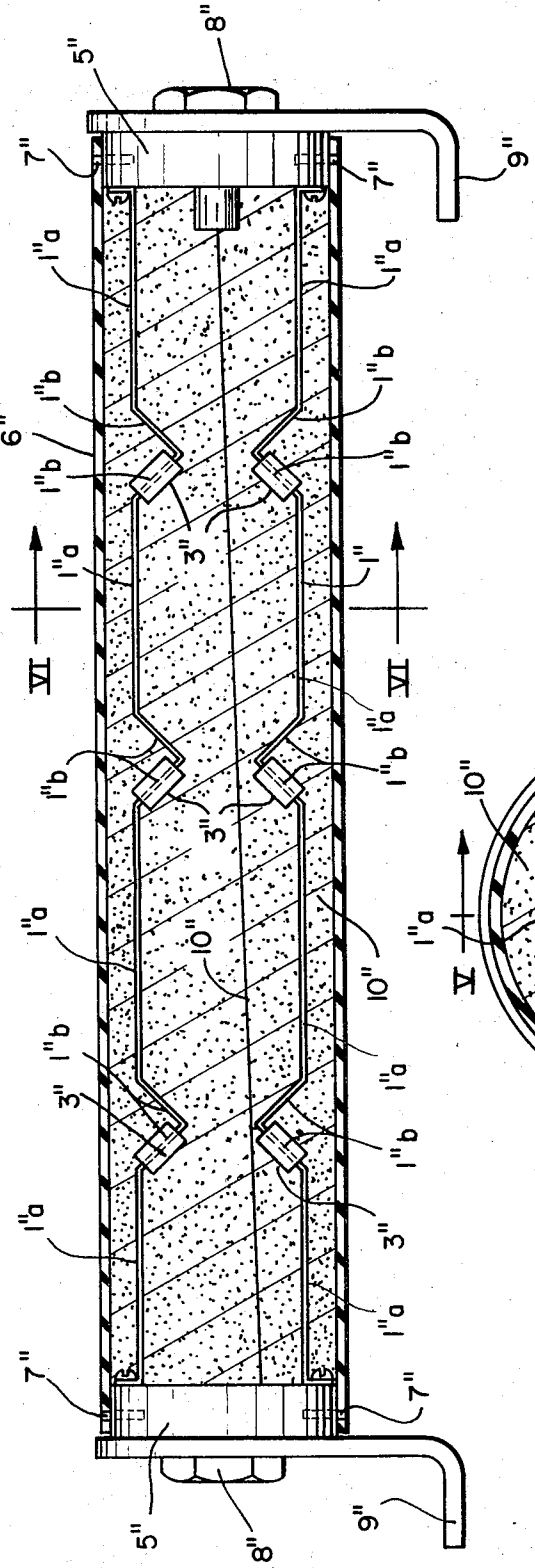
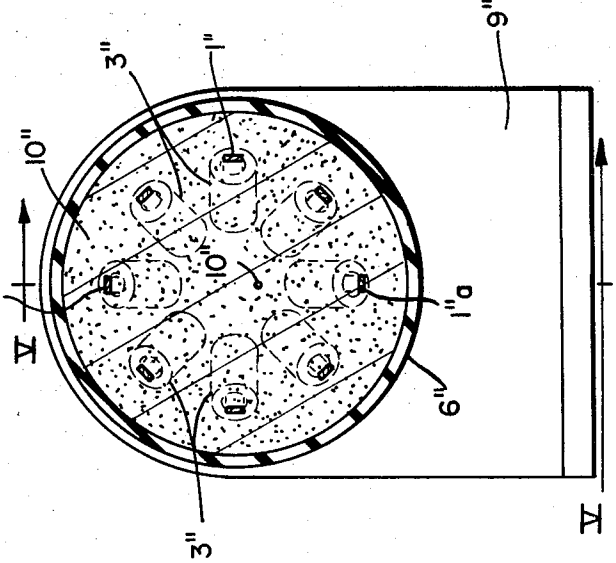


FIG. 6



ELECTRIC FUSE FOR ELEVATED CIRCUIT VOLTAGES HAVING A PLURALITY OF RIBBON FUSE LINKS CONNECTED IN PARALLEL

This invention relates to an improvement of the fuses disclosed in the copending patent application of Frederick J. Kozacka, filed 05/04/72, Ser. No. 250,175 for HIGH-VOLTAGE FUSE HAVING FULL RANGE CLEARING ABILITY and is a continuation-in-part of that application.

BACKGROUND OF THE INVENTION

This invention relates also to an improvement of the fuses disclosed in U.S. Pat. No. 3,743,994 to Frederick J. Kozacka, July 3, 1973 for RIBBON-TYPE FUSIBLE ELEMENT FOR HIGH-VOLTAGE FUSES AND FUSE INCLUDING THE ELEMENT.

The above referred-to patent application and patent disclose fuses having fusible elements supporting pellets of a material which has a relatively small thermal conductivity and evolves arc-quenching gases under the action of electric arcs. The pellets are preferably of a melamine resin and an inorganic non-tracking filler material. The fusible element or elements have serially arranged points of relatively large cross-sectional area alternating with points of relatively small cross-sectional area. The length of the pellets should exceed the spacing between two contiguous points of relatively large cross-sectional area of the fusible element or elements and exceed the spacing between two contiguous points of relatively small cross-sectional area of the fusible element or elements, both said spacings being equal. The presence of such pellets makes it possible to achieve full range interrupting or clearing ability within the meaning stated above when combined with the action of metal-severing low fusing point overlays —e.g., of tin — on the fusible element or elements which overlays are covered by the pellets.

The aforementioned U.S. Pat. No. 3,743,994 is to the effect that in the presence of several parallel connected fusible elements the fusible elements may be provided at some or all the points which are covered by pellets or beads with a metal-severing low fusing point overlay. The above referred-to patent application Ser. No. 250,175 suggests that there should be a metal-severing low fusing point overlay at each point which is covered by a bead or pellet.

SUMMARY OF THE INVENTION

The present invention is predicated on the discovery that optimal performance is achieved in case of fuses having a single fusible element if each point covered by a pellet of the above description is provided with a link-severing low fusing point overlay, but that optimal performance is achieved in case of fuses having several parallel-connected fusible elements if each element has at least one link-severing low fusing point overlay covered by a pellet of the above description, and also supports at least one pellet of the above description which is mounted on a point of each fusible element having no link-severing low fusing point overlay. The reasons confirming the correctness of this discovery are stated below in detail.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram explaining the optimal operation of fuses having but one single fusible element under small overload conditions;

FIGS. 2–4 are diagrams explaining the optimal operation of fuses having a plurality of parallel connected fusible elements under small overload conditions.

FIG. 5 is substantially a longitudinal section taken along V—V of FIG. 6 of a fuse structure embodying this invention showing some parts thereof in elevation rather than sectionalized; and

FIG. 6 is a section taken along VI—VI of FIG. 5.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 shows in a diagrammatic fashion a fuse which has a single fusible element 1. The fusible element 1 conductively interconnects electroconductive terminals 2. Fusible element 1 has 17 circular perforations forming 17 serially related points of reduced cross-sectional area. Fuse link 1 supports three pellets 3 of a gas-evolving insulating material having a much smaller thermal conductivity than the pulverulent arc-quenching filler (not shown) embedding fusible element 1. The curve T to the left of FIG. 1 indicates diagrammatically the temperature distribution along the fusible element 1. Basically the temperature distribution curve is a flat top curve. The temperature decreases from the flat top or plateau level toward the terminals of the fuse. At the points where pellets 3 are located the temperature exceeds the flat top level. In drawing curve T the peaks caused by pellets 3 rising above the flat top level have been shown on a much larger scale than the flat top level in order to emphasize the effect of pellets 3 on the geometry of temperature distribution. Metal-severing low fusing point overlays 4 are arranged on fusible element 1 inside of each of pellets 3 immediately adjacent a pellet-covered perforation in the fusible element 1.

It will be apparent from FIG. 1 that a peak temperature above the flat top level prevails inside of pellets 3. Therefore series multibreaks form on occurrence of relatively small overload currents by the metal-severing action of overlays 4. The relatively high temperatures prevailing at the pellet-covered points of fusible element 1 and the considerable length of pellets 3 accelerate backburn of the fusible element 1 and thus establish a relatively high arc voltage per break. The arc voltage at each point of break is further enhanced on account of the fact that the gases evolving from pellets 3 under the action of the arclets therein form dual axial gas blasts enveloping arclets which are incapable of moving away from the arc-extinguishing blasts on account of the confining action of pellets 3 which fixedly maintain the arclets in the gas blast regions.

It is virtually impossible to manufacture all the series over-lays 4 to such close tolerances that breaks are formed strictly simultaneously at all points where an overlay 4 and a pellet 3 covering the same are located. However, if the number of points where overlays 4 and pellets 3 are located is sufficiently large, the fuse is effective over the entire range of overload currents; though one or even perhaps more than one overlay-and-pellet-unit may fail to participate in the interrupting process. In other words, the structure of FIG. 1 may be provided with so many overlay-and-pellet-units, that effective series multibreaks are formed over the entire overload current range.

The operation of the fuse under major fault current conditions does not need to be considered in this context in detail. Briefly, under such conditions a break will form at each point of reduced cross-sectional area.

The fuse structure of FIG. 2 is exactly the same as that of FIG. 1 with the exception that terminal elements 2 are conductively interconnected by two fusible elements 1 rather than but only one such element. The same reference characters have been applied in FIGS. 1 and 2 to indicate like parts.

On occurrence of an overload current series multibreaks are not likely to occur in one of the fusible elements 1, say that shown on the left of FIG. 2, in the way set forth above in connection with FIG. 1. The fusible element 1 to first form a break is not likely to form additional or series breaks at the same time since it is shunted by the fusible element 1 which is still intact, say that shown to the right of FIG. 2. Simultaneous fusion of all overlays 4 and formation of series breaks in both fusible elements 1 is also unlikely to occur. Formation of a break in the fusible element 1 first to go does not result in rapid backburn since — as mentioned above — that fusible element is shunted at the time by the fusible element 1 which is still intact. The overlays 4 of the latter fuse in time and this results ultimately, i.e., with considerable delay, in the formation of series breaks in it. A period of time elapses from the time an initial break is formed in the left fusible element 1 and the time when fusion of overlays 4 on the right fusible element 1 occurs. An additional period of time elapses between the time of fusion of overlays 4 on the right fusible element and the time when series breaks are formed in the right fusible element. The second mentioned period of time may be very considerable because metallurgical reactions between an overlay metal and a base metal are relatively time consuming. Only after lapse of both above referred-to periods of time and formation of series breaks in the right fusible element 1 will the left fusible element 1 carry a sufficiently high current to burn back at such a rapid rate as to result ultimate interruption of the overload current.

Fuses as shown in FIG. 1 are time-lag fuses, i.e., relatively long periods of time elapse following occurrence of a predetermined overload current and formation of series breaks, which then results in relatively rapid interruption of the overload current. Fuses as shown in FIG. 2 differ from those of FIG. 1 in that formation of an initial break in one of the fusible elements 1 is not rapidly followed by formation of series breaks in the other of the fusible elements 1. To put it in other words, the arcing times of fuses of FIG. 2 are long.

Summmarizing the above, the fuses of FIG. 2 are capable of clearing overload currents over the entire overload current range, but involve under certain overload conditions relatively longer arcing times than the fuses of FIG. 1. Fuses as shown in FIG. 3 are not subject to this limitation.

Referring now to FIG. 3, a pair of serially perforated fusible elements or ribbons 1′ interconnect conductively a pair of terminal elements 2′ which are but diagrammatically shown in FIG. 3. The fusible elements 1′ are provided with three pellets 3′ of the same nature as shown in FIGS. 1 and 2 and previously described. The axially outer pellets 3′ cover metal-severing low fusing point overlays 4′, but the axially inner pellets 3′ cover perforations which are not associated with an overlay of the aforementioned kind. Fusible elements 1′ and pellets 3′ are submersed in a pulverulent arc-quenching filler, e.g., quartz sand (not shown).

The superior performance of the fuse structure shown in FIG. 3 in comparison to that of FIG. 2, and in particular the relatively shorter arcing times of the former under overload conditions may be explained as follows:

While the fuses of FIG. 2 have but one single break forming mechanism under overload conditions, and in particular cconditions of relatively small overloads, the fuses of FIG. 3 have under the same conditions two different break-forming mechanisms. At the points where the pellet-covered overlays 4′ are arranged, break formation results from a metallurgical reaction between the base metal of the fusible element 1′ and the overlay metal thereof, and at the points of the fusible elements 1′ covered by beads 3′ not provided with a metal-severing low fusing point overlay, break formation results primarily from fusion and vaporization of the base metal of the fusible element.

Considering the process of interrupting a very low overload current by the fuse structure of FIG. 3, at such currents initial break formation occurs at one of the four points where overlays 4′ are located. Initial formation of series breaks is improbable because of slight unavoidable tolerances at the four points where overlays 4′ are located, and because the current intensity in the fusible element 1′ first to go drops drastically the very instant s single break is formed in it. Thus the four overlays 4′ are four potential points of initial break formation, but an initial break is likely to be formed at only one of these four points. Whenever this occurs, the current in the other fusible element 1′, i.e., the one in which initially no break is formed, is likely to be sufficiently high to result in formation of a break at a pellet-covered point where there is no metal-severing low fusing point overlay within a shorter time than that required to form a break at a pellet-covered point where there is a metal-severing low fusing point overlay 4′. When a break is formed in each of both parallel-connected fusible elements 1′, the backburn at the bead-covered points of break is relatively fast and the voltage across both fusible elements may be sufficiently high to result in formation of series breaks.

The advantages of the low current interrupting principle embodied in the structure of FIG. 3 over the low current interrupting principle embodied in the structure of FIG. 2 becomes more pronounced the larger the number of parallel connected fusible elements 1′ in a FIG. 3 type structure. Considering a fuse as shown in FIG. 3 but having, for instance, 16 parallel current paths identical to the 2 parallel current paths of FIG. 3. Such an increase of current paths increases the probability that several fusible elements are initially simultaneously severed at pellet-covered points where there is an overlay 4′, and that this results in such an increase of current in the remaining fusible elements as to result in rapid break-formation therein at pellet-covered points where there is no metal-severing low fusing point overlay.

It is of importance to arrange the pellet-covered points of the fusible elements 1′ where there is an overlay 4′ as far away as possible from the median plane, or center region, of the fuse or, in other words, there should preferably not be any pellet-covered overlay near the median plane or the center region of the fuse. Because of the considerable length of the fusible elements of high-voltage fuses — e.g., about 20 inches — the region of the center of fusible elements of high voltage fuses tend to be subjected to the highest stresses resulting from thermal contraction and expansion, and

the points of highest stresses ought not to be covered by metal-severing low fusing point overlays since this tends to affect adversely the mechanical integrity of these points.

It may be mentioned in this context that it is known in low voltage fuses to arrange metal-severing low fusing point overlays either at the center of the fusible element or off the center thereof. The positioning of the metal-severing low fusing point overlay in a low voltage fuse is primarily dictated by the time-current curve one wishes to obtain, and to this end the metal-severing low fusing point overlay is arranged either at the region of maximum temperature, or near the center of the fusible element, or off the region of maximum temperature, or remote from the center of the fusible element. These conditions do not apply to high voltage fuses of sufficient length to result in a flat top temperature distribution curve, or to result in a curve where all the points where pellets 3' are located are substantially at the same temperature when the fuse carries current.

Given a large number of parallel current paths, the structure of FIG. 3 has the advantage of maximizing the probability of formation of simultaneous initial breaks in several of their current paths. The structure of FIG. 3 is, however, subject to the limitation that the number of breaks subsequently formed by fusion of a fusible element inside of a pellet 4' rather than by a metallurgical reaction between base metal and overlay metal is limited. This is a condition which might not be acceptable, or desirable, where the circuit voltage is high and the number of pellets 4' per fusible element 1' must be kept as small as possible. In the particular case of FIG. 3 initial formation of a break at one of the four overlays 4' of the two fusible elements 1' might result in formation of one single break at the center of the remaining fusible elements rather than formation of series breaks therein.

FIG. 3 is, in fact, but a diagrammatic representation, and the required number of series breaks can always be achieved with the structure of FIG. 3 by increasing on each fusible element the number of pellet-covered points of reduced cross-sectional area from which a low fusing point link-severing overlay is absent. FIG. 4 shows diagrammatically a modification of the structure of FIG. 3 capable of producing a relatively large number of series breaks with a relatively small number of pellets per fusible element. FIG. 4 shows diagrammatically two terminal elements 2'' conductively interconnected by four fusible elements 1'', formed by perforated silver ribbons. Each fusible element 1'' supports three pellets 3''. Two of these three pellets 3'' cover points of reduced cross-sectional area from which a metal-severing overlay is absent. One single axially outer pellet-covered point of each fusible element 1'' is provided with a metal-severing low fusing point overlay 4''. The four fusible elements 1'' form two groups. The overlays 4'' of one of said groups are arranged within pellets 3'' positioned at points relatively close to one of terminal elements 2'', and the overlays 4'' of the other of said groups are arranged within pellets 3'' positioned at points relatively close to the other of the two terminal elements 2''.

Assuming that a small overload current results in initial formation of a single break in one of overlays 4'' in the fusible element 1'' at the left end and in the formation of a single break at one of overlays 4'' in the fusible element 1'' at the right end of the array formed by four fusible elements 1''. This is likely to cause formation of two series breaks in each of the remaining fusible elements 1'' at points thereof covered by pellets 3'' and lacking overlays 4''. At this point of the interrupting process there are six points of breaks, or six arclets, inside the fuse which are substantially equally distributed along the length of the fuse. Thus heat generation inside the fuse is fairly evenly distributed.

It will be understood that retaining the basic geometry of the fuse structure shown in FIG. 4 but considerably increasing the number of fusible elements results in a greater probability of simultaneous formation of a larger number of single breaks in the axially outer portion of the array of fusible elements. This, in turn, results in a greater probability that the load subsequently carried by the remaining fusible elements of the array will form series breaks at the pellet-covered points thereof which have no metal-severing overlays.

FIGS. 5 and 6 show an actual embodiment of the invention diagrammatically shown in FIG. 4. The fuse has a voltage rating of 5.5 Kv. At this voltage level the provision of three pellets 3'' of a substance including inorganic ingredients and a melamine resin binder per fusible element has found to be sufficient for interruption of overload currents as low as the one hour fusing current and currents so low as to require several hours for causing fusion of at least one pellet-covered metal-severing low fusing point overlay, thus initiating the low current-interrupting process. The fuse shown in FIGS. 5 and 6 has eight fusible elements 1'' connected in parallel and an E rating of 150 E. Fusible elements 1'' interconnect conductively the terminal elements 5'' in the form of plugs closing tubular casing 6'' at the ends thereof. Steel pins 7'' projecting through casing 6'' into plug terminals 5'' firmly affix the latter to the former. Hex screws 8'' project through straps 9'' into plug terminals 5'' and thus secure the former to the latter. One of these hex screws may house a blown fuse indicator of the kind disclosed in U.S. Pat. No. 3,621,433 to Richard A. Belcher, Nov. 16, 1971 for ELECTRIC CARTRIDGE FUSE HAVING PLUG TERMINALS. Reference numeral 10'' has been applied to indicate the restraining wire by which the blown fuse indicator is normally held in its nonindicating position. Each of fusible elements 1'' includes relatively long sections 1''*a* extending substantially parallel to the axis of casing 6'' and relatively short sections 1''*b* slanting relative to said axis of said casing. The pellets 3'' are mounted on and supported by said relatively short sections 1''*b*. Sections 1''*b* of fusible elements 1'' have a length but slightly exceeding the length of each of pellets 3'', so that each of pellets 3'' is substantially fixedly positioned within casing 6'' by virtue of the angular relation of sections 1''*a* and sections 1''*b* of fusible elements 1''. The 8 fusible elements 1'' of the structure of FIGS. 5 and 6 includes four pairs of fusible elements 1'' arranged substantially symmetrically relative to vertical planes bisecting casing 6'', the paper on which FIG. 5 is drawn being one of these planes. The short sections 1''*b* of each said pairs 1'' of fusible elements converge toward points of intersection, i.e., imaginary points of intersection, positioned substantially along the axis of casing 6''. This arrangement of parts is extremely compact and does not require any special fastener means for pellets 3''. The bends in fusible elements 1'' used for fixedly positioning pellets 3'' further serve the purpose of precluding excessive stresses in fusible ele-

ments 1'' due to thermal expansion and contraction thereof. Brackets 9'' affixed by hex screws 8'' to terminal plugs 5'' are intended to support the fuse structure of FIGS. 5 and 6 and to connect the same into an electric circuit. The pulverulent arc-quenching filler 10'' formed by particles of quartz surrounds all parts inside casing 6'', i.e., fusible elements 1'', pellets 3'' and the restraining wire 10'' for the blown fuse indicator. Two of the 3 pellets 3'' of each fusible element 1'' are arranged at points of reduced cross-sectional area of fusible elements 1'' lacking a metal-severing low fusing point overlay, and the third of the three pellets of each fusible element 1'' is arranged at a point of reduced cross-sectional area of fusible elements 1'' at which a metal-severing low fusing point overlay is present. The presence and absence, respectively, of metal-severing low fusing point overlays has not been shown in FIGS. 5 and 6. It will be understood that this feature has been fully shown in FIG. 4 and described in its context.

I claim as my invention:

1. An electric fuse for elevated ciruit voltages including

a. a tubular casing of electric insulating material;

b. a pair of electroconductive terminal elements closing the ends of said casing;

c. a pulverulent arc-quenching filler of quartz particles inside said casing;

d. a plurality of fusible elements forming parallel current paths conductively interconnecting said pair of terminal elements, each of said plurality of fusible elements having serially arranged alternating points of relatively small cross-sectional area and of relatively large cross-sectional area;

e. a plurality of metal-severing low fusing point overlays on said plurality of fusible elements, at least one of said plurality of metal-severing low fusing overlays being supported by each of said plurality of fusible elements, and

f. a plurality of pellets of a gas-evolving material having a smaller thermal conductivity than said arc-quenching filler mounted on and supported by each of said plurality of fusible elements, said plurality of pellets having holes therein allowing each of said plurality of fusible elements to be threaded through one of said holes, and each of said plurality of fusible elements supporting at least one of said plurality of pellets arranged to cover one of said plurality of metal-severing low fusing point overlays, and each of said plurality of fusible elements further supporting at least one of said plurality of pellets arranged to cover one of said points of relatively small cross-sectional area from which a metal-severing low fusing point overlay is absent.

2. An electric fuse as specified in claim 1 wherein said plurality of pellets are of a substance including inorganic ingredients and a melamine resin binder.

3. An electric fuse as specified in claim 1 wherein each of said plurality of fusible elements is provided with at least one of said plurality of metal-severing low fusing point overlays positioned at a first point relatively close to one of said pair of terminal elements and relatively remote from the median plane of said casing, and wherein each of said plurality of fusible elements is provided with at least one of said plurality of pellets positioned at a second point relatively remote from each of said pair of terminal elements and relatively close to said median plane of said casing, and at which second point none of said plurality of metal-severing low fusing point overlays is present.

4. An electric fuse as specified in claim 3 wherein said plurality of fusible elements includes two groups of fusible elements each having substantially the same number of fusible elements, and wherein the constituent fusible elements of one of said groups are each provided with one of said plurality of metal-severing low fusing point overlays arranged within one of said plurality of pellets and positioned at a point relatively close to one of ssid pair of terminal elements, and wherein the constituent fusible elements of the other of said groups are each provided with one of said plurality of metal-severing low fusing point overlays arranged within one of said plurality of pellets and positioned at a point relatively close to the other of said pair of terminal elements.

5. An electric fuse as specified in claim 1 wherein each of said plurality of fusible elements includes relatively long sections extending substantially parallel to the axis of said casing and relatively short sections slanting relative to said axis of said casing, each said plurality of beads being mounted on one of said relatively short sections and said relatively short sections having a length but slightly exceeding the length of each of said plurality of beads so that each of said plurality of beads is substantially fixedly positioned within said casing by virtue of the angular relation of said relatively short sections and said relatively long sections of said plurality of fusible elements.

6. An electric fuse as specified in claim 5 wherein said plurality of fusible elements includes pairs of fusible elements arranged substantially symmetrically relative to planes bisecting said casing, and wherein said pairs of fusible elements include pairs of relatively short sections converging toward points of intersection positioned substantially along the axis of said casing.

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