United States Patent

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[54] **MULTI-FUSE-LINK HIGH-VOLTAGE FUSE HAVING A LINK-SUPPORTING MANDREL AND MEANS FOR EQUALIZING THE INTERRUPTING DUTY OF THE FUSE LINKS**
7 Claims, 4 Drawing Figs.

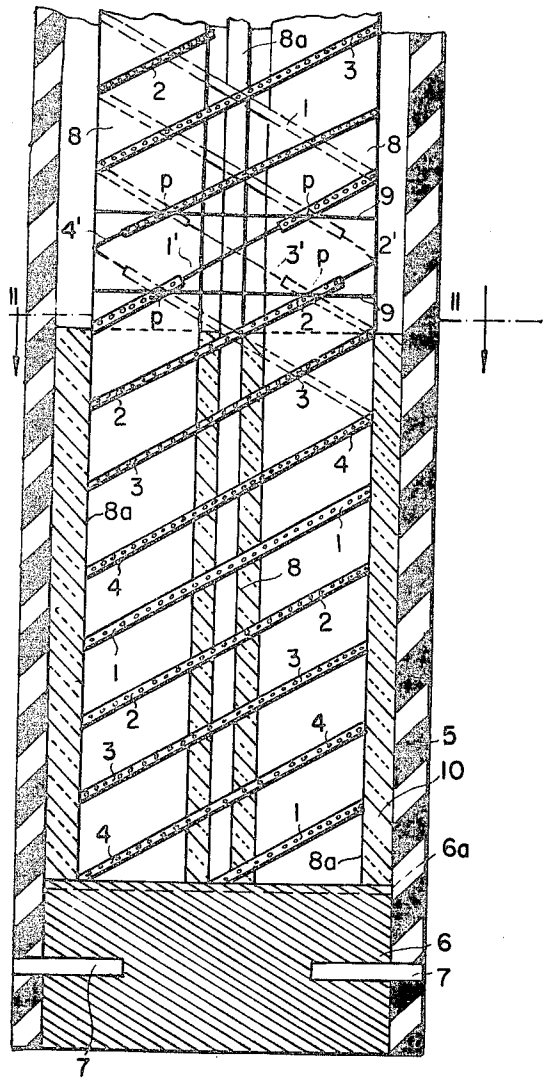
[52] U.S. Cl. 337/161, 337/276, 337/292
[51] Int. Cl. H01h 85/04
[50] Field of Search 337/159, 161, 290, 292, 221, 276

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ABSTRACT: A high-voltage fuse of the kind wherein a plurality of ribbon fuse links are wound around a mandrel structure in helical paths. The fuse further includes a pair of axially spaced auxiliary conductors wound around the mandrel structure adjacent the center region thereof and intersecting each of said plurality of fuse links at a predetermined acute angle. The pair of auxiliary conductors intersect said plurality of fuse links preferably at points where the latter are supported by said mandrel structure, and spot welds located at these points establish connections between said pair of auxiliary conductors and said plurality of fuse links.



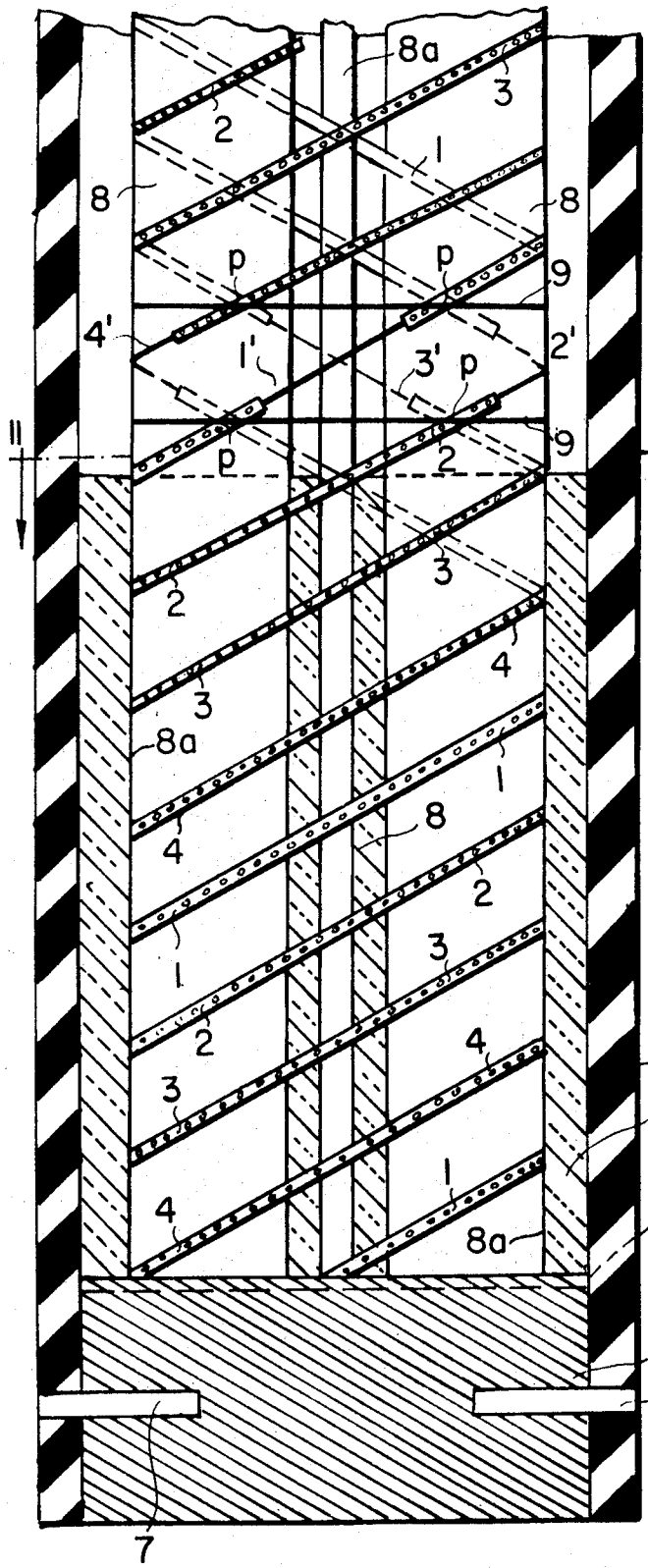


FIG. 1

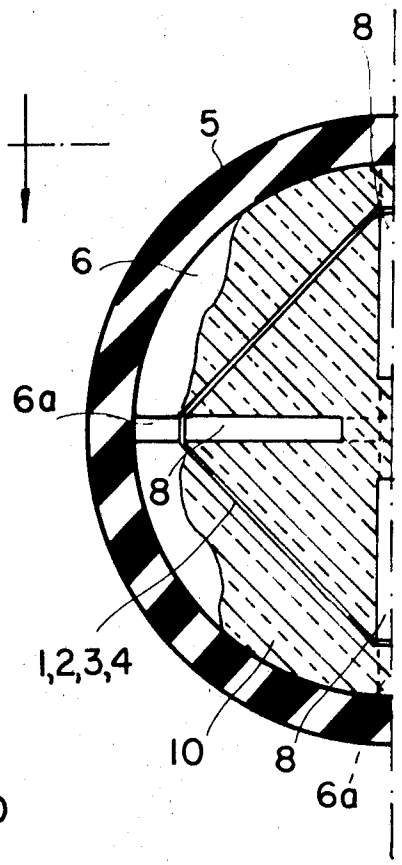


FIG. 2

INVENTOR:

Hermann Kalpen

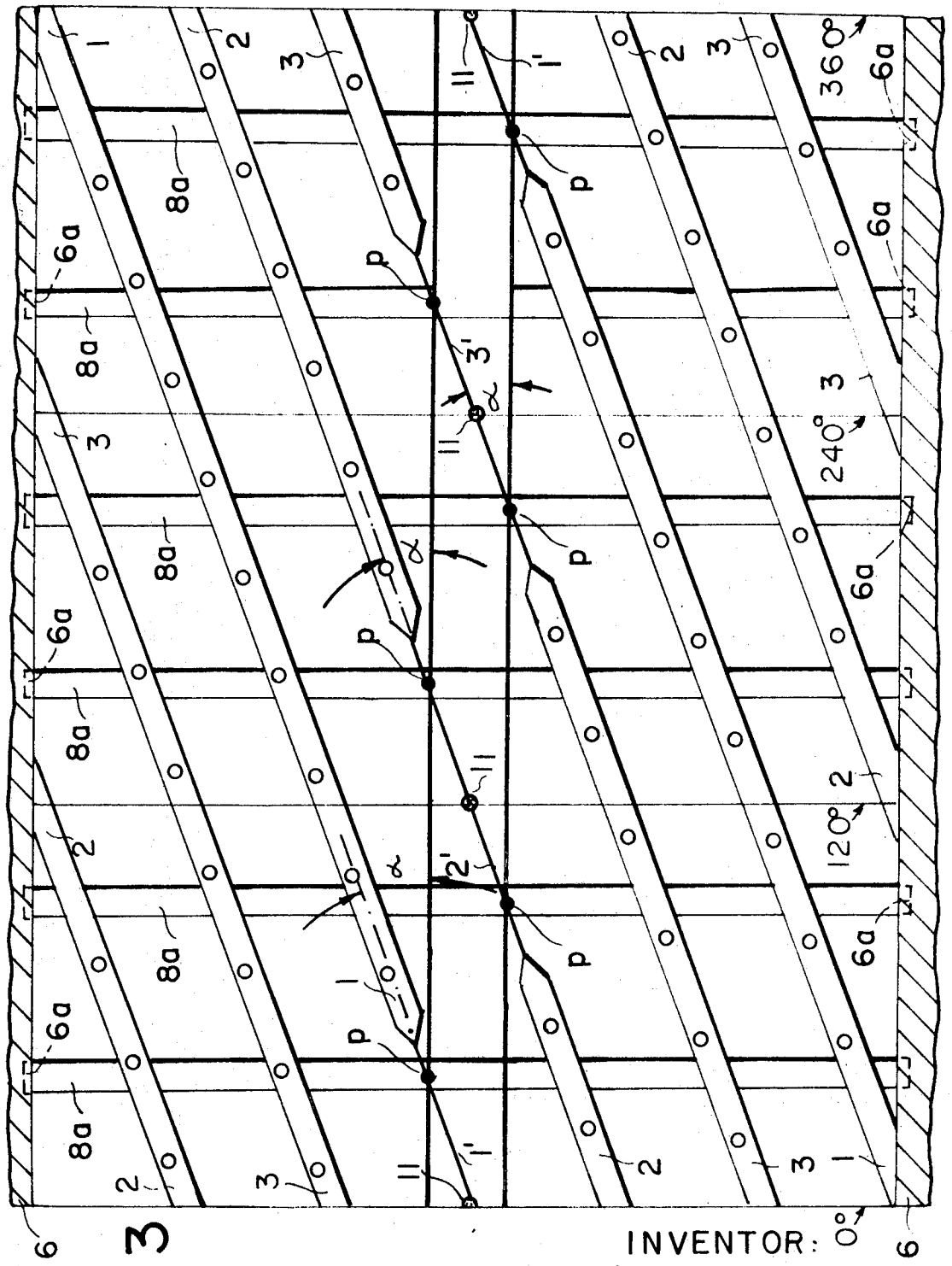


FIG. 3

INVENTOR:

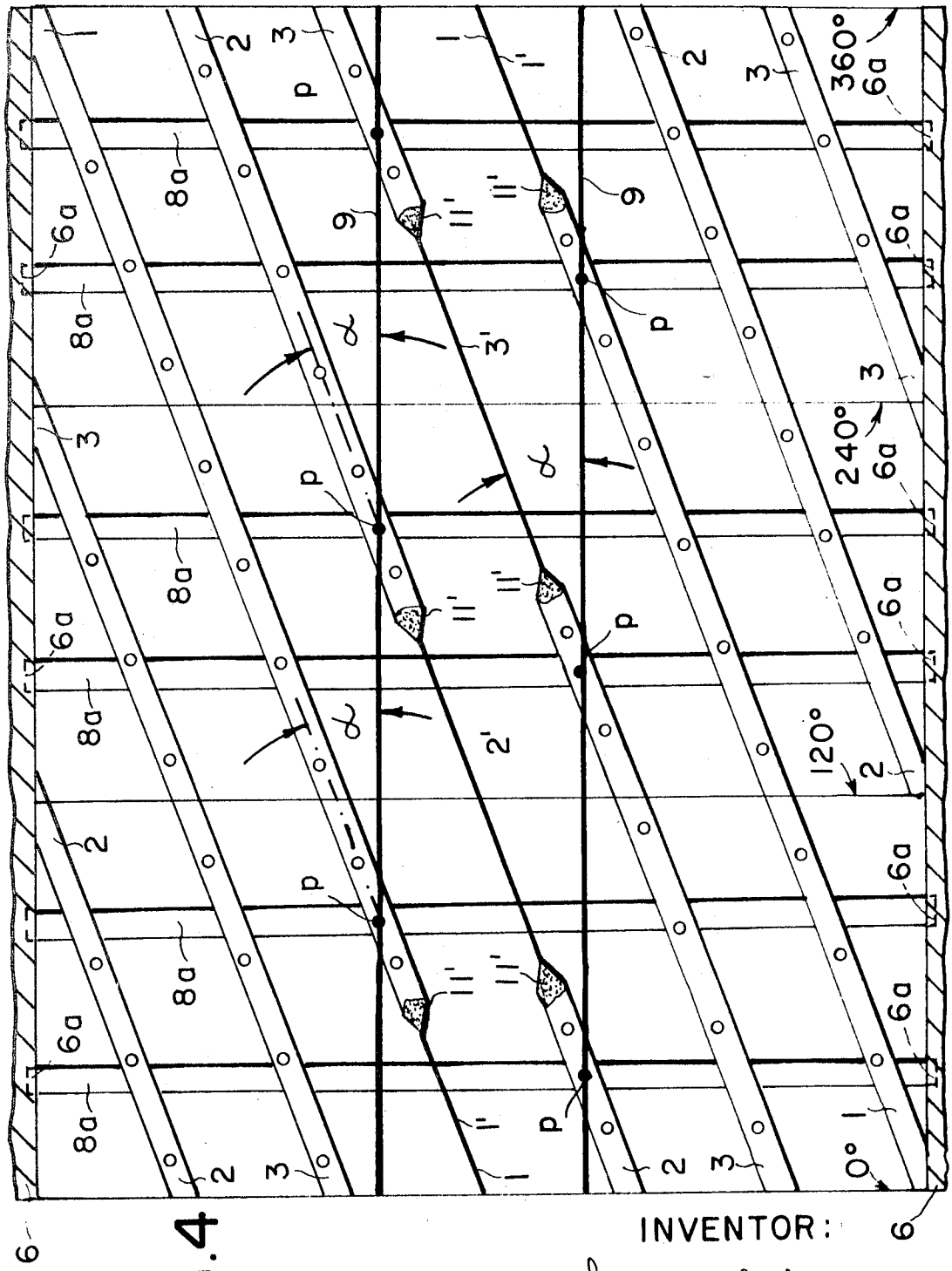


FIG. 4

MULTI-FUSE-LINK HIGH-VOLTAGE FUSE HAVING A LINK-SUPPORTING MANDREL AND MEANS FOR EQUALIZING THE INTERRUPTING DUTY OF THE FUSE LINKS

BACKGROUND OF INVENTION

A requirement generally occuring in the design of high-voltage fuses is to arrange its fuse links inside of a casing in such a way that the length of each of the fuse links exceeds considerably the length of the casing. This may be achieved by imparting a helical configuration to each of the fuse links. The requirements to carry relatively high currents and to exhibit predetermined characteristics resulted in a tendency of substitution of ribbon fuse links for fusible wires which were largely used in earlier times as fusible elements in high-voltage fuses. Ribbon fuse links ought to be narrow and thin, at least in a number of important applications. Narrow and thin ribbon fuse links must be supported by an insulating mandrel structure when their configuration is helical to achieve a large, and hence favorable, ratio of their length to the length of the fuse-link-receiving casing. Ribbon fuse links for high-voltage fuses are provided with serially related short neck portions to form series breaks on occurrence of relatively large fault currents, or short circuit currents. For interruption of protracted relatively small overload currents the ribbon fuse links of high-voltage fuses are preferably provided with an axially inner section forming a relatively long neck portion. Thus there are many relatively short neck portions to either side of the relatively long neck portion of a ribbon high-voltage fuse link, and the total length of the fuse link provided with relatively short neck portions by far exceeds the length of the axially inner section of the fuse link forming a relatively long overload current interrupting neck portion. Because the number of serially related short neck portions of a ribbon fuse link for high-voltage fuses is very large, even slight unavoidable manufacturing tolerances add up and result in that the resistance of the axially outer sections of high-voltage fuses differ slightly but significantly from fuse link to fuse link. This initial difference from fuse link to fuse link may be increased by their handling, and by the process of winding the same helically upon a mandrel. The differences between different fuse links which go into a high-voltage fuse result in that the different constituent fuse links of a high-voltage fuse do not equally share the total current carried by the fuse. The deviations between the constituent fuse links of a high-voltage fuse tend to increase the longer the fuse links, and the larger the number of serially related relatively short neck portions they have or, in other words, the higher their voltage rating is, and the higher the arc voltages they are supposed to generate. As a result of these and other differences between the fuse links of a high-voltage fuse their axially inner sections forming relatively long necks for the interruption of protracted overload currents are hardly ever at exactly the same temperature, and hence hardly ever sever their respective current paths at the same time. Such sequential formation of breaks at the constituent fuse links of a high-voltage fuse on occurrence of protracted overload currents may be permissible in certain circumstances, but in other circumstances sequential formation of breaks may result in failure of any particular fuse. In instances where sequential formation of breaks in high-voltage fuses is not permissible, or undesirable, measures ought to be taken to synchronize arc initiation at all fuse links connected in parallel in a given high-voltage fuse. Synchronization of arc initiation must not be absolute. Arcs are sufficiently synchronized if the arc formed at the fuse link at which an arc is formed last is formed before all other parallel arcs are extinguished.

In this context it seems to be in order to point out that while parallel arcs in a gaseous medium are unstable and cannot coexist on account of their negative current-voltage characteristic, arcs in a pulverulent medium such as quartz sand are not necessarily unstable but can coexist not having a negative current-voltage characteristic.

One prior art means for synchronizing arc initiation in a high-voltage fuse including a plurality of ribbon fuse links which are connected in parallel and wound helically upon a common mandrel is to impart a shorter length to the mandrel than the length of the casing, and to establish a common point, or electrical junction, of all fuse links to which all fuse links converge. This way of designing a high-voltage fuse has serious limitations, or drawbacks. It results in a drastic reduction of the ratio of the length of each of the fuse links to the length of the casing. In addition to that fact it results in a tendency of thermal overloading, or overstressing, the pulverulent arc-quenching filler at the aforementioned common point or electrical junction. Therefore, this point tends to have a relatively high conductivity after interruption of an overload current and this, in turn, is conducive to failure of the particular fuse upon interruption of an overload current by it.

The high-voltage fuses embodying this invention are not subject to the aforementioned limitations and drawbacks of high-voltage fuses including means for the synchronization of arc initiation at the several helically wound mandrel-supported fuse links thereof on occurrence of overload currents of inadmissible duration.

SUMMARY OF INVENTION

Fuses embodying this invention include a tubular casing of insulating material and a pair of metallic terminal elements closing the ends of the casing. An elongated fuse link-supporting mandrel structure of insulating material inside the casing is arranged in a direction longitudinally thereof. The mandrel structure has radial ribs including radially outer edges extending parallel to the axis of the casing. The pair of terminal elements is conductively interconnected by a plurality of ribbon fuse links wound around the mandrel structure in substantially helical angularly displaced paths and supported at spaced discrete points thereof by the radially outer edges of the radial ribs of the mandrel structure. Each of said plurality of fuse links has a pair of axially outer sections provided with serially related relatively short neck portions and an axially inner section forming a relatively long neck portion.

The gist of the invention consists in providing a high-voltage fuse of the above description with a pair of axially spaced auxiliary conductors wound around the mandrel structure adjacent the center region thereof and intersecting each of said plurality of fuse links at a predetermined acute angle.

Said pair of auxiliary conductors and said plurality of fuse links are preferably joined by spot welds located at points where said pair of auxiliary conductors intersect said plurality of fuse links and said plurality of fuse links are supported by said radially outer edges of said radial ribs of said mandrel structure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is partly a side elevation and partly a vertical section of a high-voltage fuse embodying the present invention, the upper portion of the fuse structure being broken away and some portions of the lower end thereof also being broken away to expose to view internal parts of the fuse structure;

FIG. 2 is a section along II—II of FIG. 1;

FIG. 3 is a diagrammatic representation in form of a development of an entire fuse embodying this invention; and

FIG. 4 is another diagrammatic representation in form of a development of an entire fuse embodying this invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

In FIGS. 1 and 2 of the drawings reference numerals 1, 2, 3 and 4 have been applied to indicate four ribbon fuse links having helical configurations. A tubular casing 5 of insulating material houses fuse links 1, 2, 3, 4. Casing 5 is closed on the ends thereof by terminal elements in the form of terminal plugs 6 press fitted into the ends of casing 5 and firmly maintained in position by steel pins 7 projecting transversely through casing 1 into plugs 6. FIG. 1 shows but the lower end

of a fuse with its closing plug 6 and its steel pin 7. The upper end of the fuse is exactly the same as its lower end. The axially inner ends of terminal plugs 6 are each provided with a pair of grooves 6*a* intersecting at right angles at the center of cylindrical plugs 6. Four elongated insulating plates 8 are inserted with their axially outer edges into the grooves 6*a* of terminal plugs 6. This is clearly shown in FIGS. 1 and 2 in regard to lower terminal plug 6, and the arrangement of plates 8 in regard to upper plug 6 not shown in FIGS. 1 and 2 is the same as shown in these figures in regard to the lower end of the fuse structure. Plates 8 are preferably made of a ceramic material. Since plates 8 are subjected to the heat of electric arcs they must be heat resistant and preferably heat-shock resistant. The four elongated plates 8 form a fuse-link-supporting mandrel for fuse links 1, 2, 3, 4 arranged inside of casing 5 in a direction longitudinally thereof. Plates 8 are in effect radial ribs of a link-supporting mandrel including radially outer edges 8*a* extending parallel to the axis of casing 5. Fuse links 1, 2, 3, 4 are wound helically around the mandrel structure formed by plates 8. The helical paths of fuse links 1, 2, 3, 4 are angularly displaced 90°. Thus the bottom end of fuse link 1 is situated at the front of lower plug 6, the bottom end of fuse link 2 is situated at the right side of lower plug 6 and displaced 90° relative to the bottom end of fuse link 1, the bottom end of fuse link 3 is situated at the rear of lower plug 6 and displaced 90° relative to the bottom end of fuse link 2, and the bottom end of fuse link 4 is situated at the left side of lower plug 6 and displaced 90° relative to the bottom end of fuse link 3. Helical fuse links 1, 2, 3, 4 are supported at spaced discrete points thereof by the radially outer edges 8*a* of radial ribs or plates 8. Each fuse link 1, 2, 3, 4 includes a pair of axially outer sections having serially related relatively short neck portions and an axially inner section forming a relatively long neck portion. The term neck portion is applied in reference to points of the fuse links 1, 2, 3, 4 of reduced cross-sectional area and of reduced width. The aforementioned relatively short neck portions may be formed by circular perforations as clearly shown in the drawings. Upon occurrence of a major fault or short circuit current the relatively short neck portions fuse substantially simultaneously, resulting in the formation of short series arcs. The axially inner sections of fuse links 1, 2, 3, 4 forming relatively long neck portions have been designated by the reference characters 1′, 2′, 3′, 4′. Reference numeral 9 has been applied to indicate a pair of axially spaced auxiliary conductors wound around mandrel structure 8, 8, 8, 8 adjacent the center region thereof. Auxiliary conductors 9 are supported at spaced discrete points by the radially outer edges 8*a* of radial ribs 8 and they intersect at a predetermined acute angle α (see FIGS. 3 and 4) the helically wound fuse links 1, 2, 3, 4.

On occurrence of major fault currents series breaks and short series arcs are formed at each short neck of fuse links 1, 2, 3, 4. Fuse links 1, 2, 3, 4 are embedded in a pulverulent arc-quenching filler 10, preferably quartz sand, resulting in a rapid quenching of these series arcs and interruption of the faulted circuit. In FIG. 1 casing 5 has been shown as being only partly filled with filler 10. Actually casing 1 is filled entirely with quartz sand or a similar arc-quenching filler.

On occurrence of relatively small overloads of inadmissible duration the interrupting process is initiated at the axially inner sections 1′, 2′, 3′, 4′ of fuse links 1, 2, 3, 4. The axially outer sections of fuse links 1, 2, 3, 4 are of considerably greater length than the length of the axially inner sections 1′, 2′, 3′, 4′, and are provided with a relatively large number of serially related relatively short neck portions formed by circular perforations of which each may slightly deviate from the other. Therefore the resistance of the axially outer sections of fuse links 1, 2, 3, 4 and the $I^2 \cdot r$ losses occurring therein may significantly deviate from each other. In other words, due to the relatively long length of the axially outer sections of fuse links 1, 2, 3, 4 and the relatively large number of short neck portions therein, there is a marked tendency that the currents carried by fuse links 1, 2, 3, 4 will slightly deviate from each other. As a result, there is a tendency that the temperatures of the axially inner overload interrupting neck portions 1′, 2′, 3′, 4′ of fuse links 1, 2, 3, 4 differ from each other and that neck portions 1′, 2′, 3′, 4′ form circuit interrupting breaks at times which are relatively far apart. This tendency is counteracted, or completely avoided, by the presence of auxiliary conductors 9, operating as temperature equalizers.

Conductors 9 may be formed by narrow flat silver ribbons or round silver wires. Even round silver wires of relatively small cross-sectional area, i.e. of a cross-sectional area substantially less than the cross-sectional area of fuse links 1, 2, 3, 4 will operate as effective temperature equalizers. It takes considerable periods of times for small overload currents to form breaks at the relatively long axially inner neck portions 1′, 2′, 3′, 4′. Since the time available for conductors 9 to equalize the temperature at both ends of axially inner necks 1′, 2′, 3′, 4′ is relatively long their cross-sectional area needs to be but relatively small.

To facilitate heat exchange between fuse links 1, 2, 3, 4 and the pair of auxiliary conductors 9 at their points *p* of intersection auxiliary conductors 9 are spotwelded to ribbon fuse links 1, 2, 3, 4 at each point *p* of intersection thereof.

FIGS. 3 and 4 show substantially the same structure as FIGS. 1 and 2 and the same reference characters have been applied in all figures to indicate like parts. The structures of FIGS. 3 and 4 include but three helically wound ribbon fuse links 1, 2, 3 angularly displaced 120°.

In FIGS. 3 and 4 the auxiliary conductors 9, the fuse links 1, 2, 3 and the radially outer edges 8*a* of mandrel-forming ribs 8 are arranged in such a way that the points of intersection of auxiliary conductors 9 with fuse links 1, 2, 3 are coextensive, or in registry, with the points where fuse links 1, 2, 3 are supported by the radially outer edges 8*a* or ribs or plates 8. This feature is of importance because it facilitates to tack auxiliary conductors 9 by spotwelds to fuse links 1, 2, 3. In the arrangement of FIG. 1 the points of intersection *p* of conductors 9 and fuse links 1, 2, 3, 4 are not coextensive, or in registry, with the points of support of fuse links 1, 2, 3, 4 by the radially outer edges 8*a* of radial ribs or plates 8.

FIG. 3 shows an arrangement wherein the auxiliary conductors 9 intersect the fuse links 1, 2, 3 at the axially inner sections 1′, 2′, 3′, 4′ forming relatively long neck portions, and FIG. 4 shows an arrangement wherein the auxiliary conductors 9 intersect fuse links 1, 2, 3 at the axially outer sections between a pair of circular perforations forming relatively short neck portions.

The auxiliary conductors 9 will be vaporized by arcing when the backburn of the neck portions 1′, 2′, 3′ is sufficiently long. Hence the metal of which auxiliary conductors 9 are made ought to have as small a melting $i^2 \cdot t$ as possible, i.e. auxiliary conductors 9 ought to be made of silver. Round silver wires are quite satisfactory.

The neck portions 1′, 2′, 3′ of fuse links 1, 2, 3 may be formed by stamping operations. It is, however, preferable to form neck portions 1′, 2′, 3′ by lengths of round silver wire spotwelded at the axially outer end thereof to the axially inner ends of the axially outer sections of fuse links 1, 2, 3.

The structures of FIGS. 1 to 4 may be provided with link-severing low-fusing point overlays to reduce the temperature at which circuit interrupting breaks are formed when protracted overload currents occur and to increase the timelag in case of occurrence of such overload currents. FIGS. 3 and 4 show different arrangements of such overlays. According to FIG. 3 long neck portions 1′, 2′, 3′, are formed by round silver wires and a link-severing overlay 11, e.g. of tin, is arranged on each neck portion midway between the points *p* of intersection of auxiliary conductors 9 with neck portions 1′, 2′, 3′. The round silver wires 9 are spotwelded at points *p* to neck portions 1′, 2′, 3′ of fuse links 1, 2, 3. According to FIG. 4 the neck portions 1′, 2′, 3′ of fuse links 1, 2, 3 are likewise formed by round silver wires and links severing overlays 11′ are arranged at the ends of neck portions 1′, 2′, 3′, i.e. at the points where the latter are spotwelded to the axially outer per-

forated portions of fuse links 1, 2, 3. In FIG. 4 the points of intersection of auxiliary conductors 9 formed by round silver wires and of ribbon fuse links 1, 2, 3 have been indicated by reference character *p*. The points *p* coincide with the points where fuse links 1, 2, 3 are supported by the radially outer edges 8*a* of plates or ribs 8.

It will be noted that the structures of FIGS. 3 and 4 include terminal plugs 6 each having six radially extending grooves 6*a* for receiving mandrel-forming insulating plates having radially outer link-supporting edges 8*a*. The angular spacing between the aforementioned plates varies, i.e. the first two plates to the left of FIGS. 3 and 4 have a relatively narrow spacing, and the second and the third plate to the left of FIGS. 3 and 4 have a relatively large spacing. These spacings are repeated periodically from left to right of FIGS. 3 and 4. Since the link-supporting mandrel is fabricated of separate insulating plates held together by plugs 6 it is readily possible to meet any requirement which may arise in regard to the configuration of the radially outer link supporting edges 8*a*.

It will be understood that I have illustrated and described herein preferred embodiments of my invention and that various alterations may be made therein without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. An electric high-voltage fuse including in combination
   a. a tubular casing of insulating material;
   b. a pair of metallic terminal elements closing the ends of said casing;
   c. an elongated fuse-link-supporting mandrel structure of insulating material inside said casing arranged in a direction longitudinally thereof and having radial ribs including radially outer edges extending parallel to the axis of said casing;
   d. a plurality of ribbon fuse links conductively interconnecting said pair of terminal elements, wound around said mandrel structure in substantially helical angularly displaced paths and supported at spaced discrete points thereof by said radially outer edges of said radial ribs of said mandrel structure, each of said plurality of fuse links having a pair of axially outer sections provided with serially related relatively short neck portions and an axially inner section forming a relatively long neck portion; and
   e. a pair of axially spaced auxiliary conductors wound around said mandrel structure adjacent the center region thereof and intersecting each of said plurality of fuse links at a predetermined acute angle.

2. An electric high-voltage fuse as specified in claim 1 wherein said pair of auxiliary conductors and said plurality of fuse links are joined by spotwelds located at points where said pair of auxiliary conductors intersect said plurality of fuse links and said plurality of fuse links are supported by said radially outer edges of said radial ribs of said mandrel structure.

3. A high-voltage fuse as specified in claim 1 wherein said pair of auxiliary conductors is formed by round silver wires.

4. An electric high-voltage fuse as specified in claim 1 wherein
   a. said pair of axially outer sections of each of said plurality of fuse links is formed by silver ribbons having serially related circular perforations; wherein
   b. said relatively long neck portion of each of said plurality of fuse links is formed by a length of round silver wire spotwelded at the axially outer ends thereof to the axially inner ends of said pair of axially outer sections of each of said plurality of fuse links; and wherein
   c. said pair of auxiliary conductors is formed by a pair of round silver wires spotwelded to said plurality of fuse links at points where said pair of auxiliary conductors intersect said plurality of fuse links.

5. A high-voltage fuse as specified in claim 3 wherein
   a. said length of round silver wire forming said relatively long neck portion of each of said plurality of fuse links is provided with a pair of link-severing low fusing point overlays each adjacent to one of the axially outer ends of said length of silver wire; and wherein
   b. said pair of round silver wires forming said pair of auxiliary conductors intersect with said plurality of fuse links at points positioned axially outwardly from said pair of link-severing overlays of each of said plurality of fuse links.

6. A high-voltage fuse as specified in claim 3 wherein a link-severing low fusing point overlay is arranged on said relatively long neck portion of each of said plurality of fuse links between the points of intersection thereof with said pair of auxiliary conductors.

7. A high-voltage fuse as specified in claim 1 wherein said pair of auxiliary conductors is arranged in a pair of planes at right angles to said mandrel structure and intersects said plurality of fuse links at points where said plurality of fuse links is supported by said radially outer edges of said radial ribs of said mandrel structure, and wherein spotwelds located at these points of intersection establish connections between said pair of auxiliary conductors and said plurality of fuse links.