

July 30, 1940.

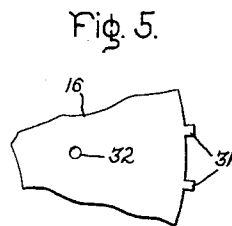
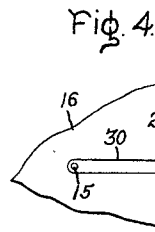
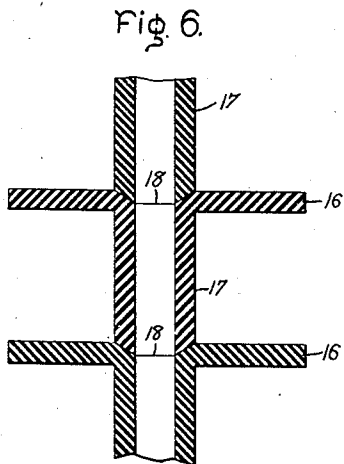
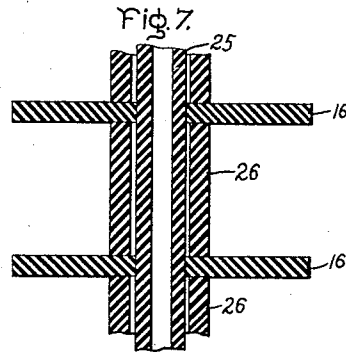
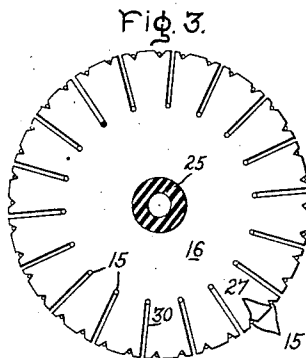
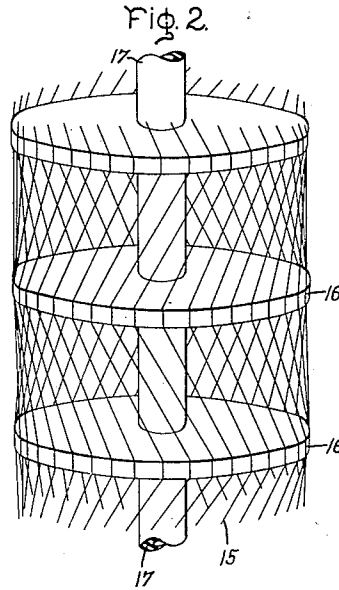
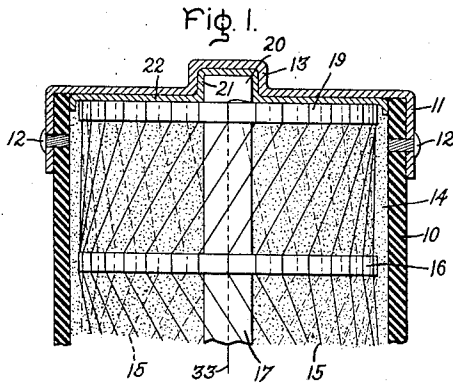
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2,209,823

FUSE

Filed Dec. 7, 1937

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 8.

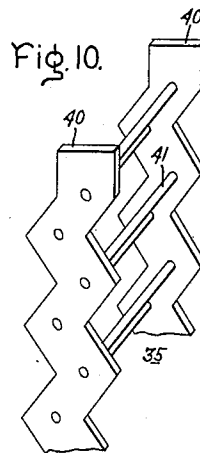
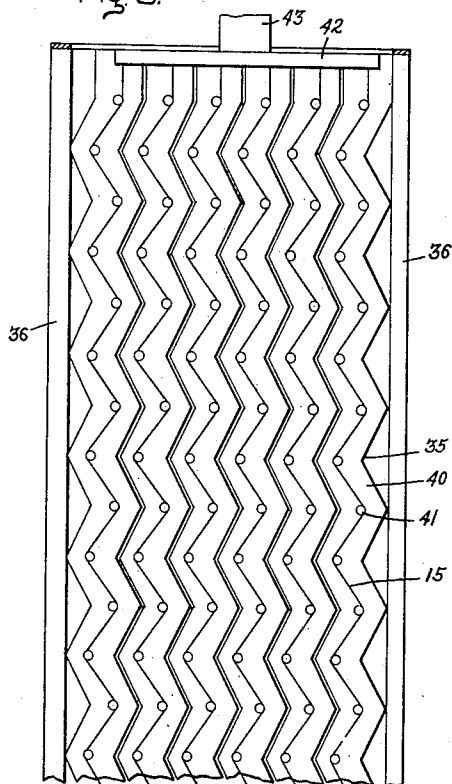


Fig. 9.

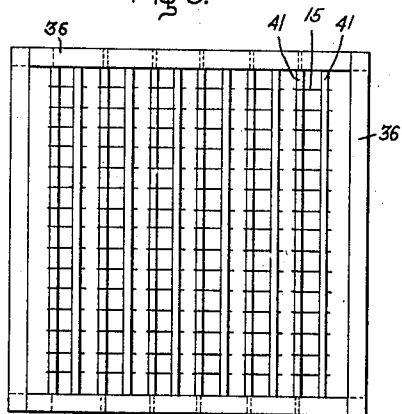


Fig. 12.

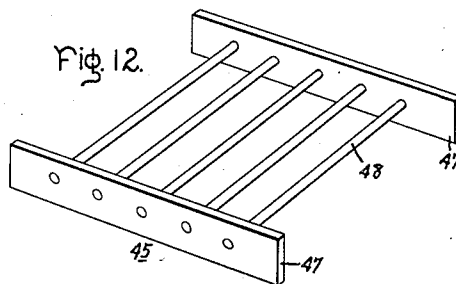
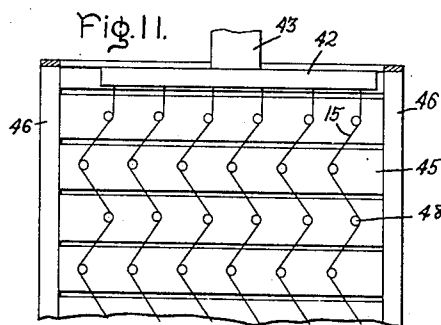


Fig. 11.



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UNITED STATES PATENT OFFICE

2,209,823

FUSE

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 In Germany December 16, 1936

13 Claims. (Cl. 200—120)

The present invention relates to fuses, and more particularly to fuses of the current limiting type wherein a fusible element is embedded in a granular, arc-quenching material.

5 An important object of the invention is the provision of an improved high voltage fuse for the interruption of very large currents, which fuse is of the type wherein a fusible element is embedded in a granular, inert, arc-quenching material such as sand or pulverized quartz.

10 When a fuse of the type referred to in the preceding paragraph is subjected to current of sufficient magnitude, the fusible element fuses and vaporizes with accompanying formation of an arc along the path of the element, and the heat and vapors of the arc are dissipated through the surrounding granular, inert, arc-quenching material. I have found that the heat of the arc causes fusion of the immediately surrounding body of material and that subsequently this fused mass solidifies into a more or less rigid shell surrounding the space previously occupied by the fusible element. This shell will be designated hereinafter as the "fusion shell." Although not fully understood, it is believed that the current limiting action of this type of fuse is due to the transfer of the current from the arc to the immediately surrounding mass of fused inert filling material, the conductivity of which is greatly increased upon fusion, with resultant dying out of the arc and resolidification of the fused mass, whereupon the material of the solidified fusion shell again has the high resistance value of an insulator and interrupts the flow of current therethrough.

35 I have found it advantageous in the construction of fuses of the type above referred to for interruption of extremely high currents, to subdivide the fusible element into a large number of parallel connected very fine wire conductors so as greatly to increase the conductor surface in contact with the granular, inert, filling material. This greatly facilitates the dissipation of the arc energy. I have found it advantageous also to provide a zigzag arrangement of the conductors so that the conductors sharply change their directions at frequent intervals along their lengths. The metal vapor ions developed upon fusion and vaporization of the conductors are accelerated in the direction of the electric field and, due to the zigzag arrangement, are projected against the walls of the channels in the filling material through which the conductors pass, these walls in the zigzag arrangement being perpendicular or oblique to the direction of the electric field.

Thus, the metal vapor ions are absorbed so that the current is obliged to flow through the surrounding fused filling material and the arcs are more quickly extinguished than would be the case if the conductors extended substantially in a straight line or without the frequent changes in direction afforded by the zigzag arrangement.

My present invention has, therefore, as a further and more specific object, the provision of an improved fuse construction for effecting in a practical and economical manner the desirable arrangements discussed in the preceding paragraph.

Other objects and that which I believe to be novel and my invention will become apparent from the following description and the claims appended thereto taken in conjunction with the accompanying drawings in which are illustrated exemplary fuse constructions embodying my present invention. In the drawings, Fig. 1 shows in cross-section a part of one of the exemplary fuse constructions; Fig. 2 shows in perspective a part of a supporting structure for use in the fuse of Fig. 1; Fig. 3 is a plan view of an element adapted for use as a part of the supporting structure of Fig. 2; Fig. 4 is a detail plan view of a portion of the element of Fig. 3; Fig. 5 illustrates a modification of the element of Figs. 3 and 4; Figs. 6 and 7 illustrate two methods of assembly of the supporting structure of Fig. 2; Fig. 8 illustrates diagrammatically a longitudinal cross-section of a modified form of supporting structure for use in the practice of my invention; Fig. 9 is a view looking down on the top of the structure of Fig. 8 with certain of the elements removed for clarity; Fig. 10 is a perspective view of a portion of an element of the supporting structure of Fig. 8; Fig. 11 illustrates diagrammatically a longitudinal cross-section of another form of supporting structure for carrying out my invention; and Fig. 12 shows in perspective one of the elements of the supporting structure of Fig. 11. In the interests of clarity, the various constructions are illustrated somewhat diagrammatically in the several figures and the relative sizes and spacings of the various parts are somewhat exaggerated.

The fuse of Fig. 1 is provided with an enclosing casing 10 of suitable insulation material having a metal end cap 11 which is secured to the casing by self-threading screws 12 or other suitable means and which has a cylindrical boss 13 for connection and mounting purposes. The casing is filled with a body 14 of finely divided, or granular, inert, arc-quenching material such as sand,

pulverized quartz, or the like, and embedded in this filling material are a large number of fine wire fusible conductors 15 carried by a supporting structure of the type shown in perspective in Fig. 2. This supporting structure consists in the main of a plurality of transverse disks 16 arranged in parallel extending spaced apart relationship. These disks are comprised of non-inflammable, high melting point, non-arcing, and preferably ceramic, insulating material. The positioning of the disks may be maintained in either of the two manners illustrated in Figs. 6 and 7. In the construction of Fig. 6, each of the disks 16 is provided with an integrally formed and centrally located hollow supporting and spacing tube 17. Each of the disks has also a beveled seat 18 formed on the opposite side thereof from its tube 17, which seat is adapted to receive the beveled end of the tube 17 of the next adjacent disk. Any desired number of units, each comprised of a disk 16 and its integrally formed tube 17, may be secured end to end, by cementing or other suitable method, to provide a supporting structure of any desired length. When the supporting structure is mounted within casing 10, there may be provided end disks 19 which have tubular bosses 20 adapted to fit in hollow bosses 21 of metal terminal plates 22, one of which is shown in the drawings. As shown in Fig. 1, the boss 21 of the terminal plate 22 fits into the terminal boss 13 of end cap 11 so as to maintain the positioning of the supporting structure, while the terminal plate extends outwardly over the surface of the end disk 19 to contact with the ends of the fusible conductors 15 and also extends into engagement with the inner walls of casing 10 to aid in maintaining the supporting structure in proper position.

In the construction of Fig. 7, the disks 16 are mounted on a hollow tube 25 which extends through centrally located openings in the disks, and the disks are held in properly spaced apart relation by spacing tubes 26 disposed concentrically of tube 25. Tubes 25 and 26 may be of either the same or similar material to that employed in the construction of disks 16. The method of assembly of Fig. 7 may be utilized to secure additional strength and rigidity of support but lacks the advantage of providing for the assembly of any desired number of units, as is possible with the construction of Fig. 6. The supporting structure assembled in accordance with Fig. 7 may be mounted in the enclosing casing 10 in the same manner as that described in the preceding paragraph in connection with the structure of Fig. 6.

Around the peripheries of the disks 16 are formed a large number of notches 27 for receiving the wire conductors 15. The individual conductors preferably have a diameter in the order of magnitude of 0.1 to 0.3 millimeter. In order to produce a large number of sharp changes of direction of the conductors, they are arranged on the supporting structure in zigzag formation so that they sharply change their directions at each of the points of engagement with the notches 27 of the successive disks 16. Notches 27 are arranged so as to maintain the conductors in parallel extending relationship in an imaginary cylindrical surface with the conductors uniformly spaced apart approximately the thickness of a fusion shell. I do not wish to be limited to any specific spacing since I have found that the thickness of the fusion shells varies as a function of the current interrupted and they

may attain a thickness of approximately 3.18 millimeters. It is possible for one skilled in the art to determine by experimentation the fusion shell thickness to be expected and thereby the proper spacing, in the practice of the present invention, for any particular fuse, which spacing will depend upon the current value which the fuse is designed to interrupt. Also, the number of fusible conductors employed depends upon the operating current, but it is desirable for most effective results on fuse operation that the individual conductors be limited to a diameter not greatly exceeding the upper limit given above. By the arrangement of the conductors as above described, they are prevented from interfering with each other in spite of their large number and close spacing, and the fusing process for each of the individual conductors will proceed independently of the fusing process for the others of the conductors upon fuse operation.

For economy of space where it is desired to employ a very large number of fusible wire conductors 15, there may be provided in the peripheries of disks 16, as indicated in Figs. 3 and 4, additional and deeper notches or slots 30 which may be employed to accommodate a second set of fusible conductors arranged in an imaginary cylindrical surface disposed concentrically within the imaginary cylindrical surface occupied by the outer set of conductors, as indicated in Fig. 3. Also, disks 16 may be provided, as indicated in Fig. 5, with projections 31, instead of the notches 27, for positioning the outer set of fusible conductors, and may be provided also with inwardly spaced openings 32 instead of the deep slots 30 for receiving an inner set of fusible conductors. Although disks 16 are illustrated as being circular, they may if desired be given an oval, rectangular, or other suitable shape in accordance with the shape of the particular enclosing casing employed. Moreover, the space within the hollow tubes 17 or 25 may be employed to accommodate a high resistance wire 33, connected in parallel with the fusible conductors, as is sometimes desired.

The fuse supporting structure illustrated in Figs. 8 and 10 is adapted to be accommodated in a rectangular enclosing casing and to be used where it is desired to employ a very large number of parallel connected fusible wire conductors. This supporting structure is comprised of a plurality of ladder-like frames 35 adapted to extend lengthwise of the enclosing casing and to be held in parallel side by side relation by means of a suitable framework 36. As will be seen from Fig. 10, each of the frames 35 is comprised of a pair of side members 40, of zigzag form, held in spaced apart relationship by means of insulating cross-bars 41. The successive cross-bars 41 are staggered laterally of the frame so as to support the conductors 15 in zigzag arrangement, as shown in Fig. 8. In the final assembly, the opposite ends of the conductors are connected to terminal plates 42, one of which is shown in Fig. 8, which terminal plates have terminal projections, as indicated at 43. As will be seen from Fig. 9, the arrangement just described provides for the support of a very large number of fusible conductors with the conductors maintained in closely spaced, parallel extending relationship and with the individual conductors changing their direction at frequent intervals along the lengths thereof. Cross-bars 41 may be provided with any suitable means for maintaining the conductors in properly spaced relation-

ship, the spacing, as previously pointed out, being approximately the thickness of a fusion shell where, in the final assembly, the fusible conductors are embedded in finely divided, or granular, inert, arc-quenching material, as in the embodiment of Fig. 1.

In the modified structure of Fig. 11, the conductors 15 are positioned by frames 45 adapted to extend transversely of an enclosing casing and to be held in parallel side by side relationship by means of a suitable framework 46. As will be seen from Fig. 12, each of the frames 45 is comprised of a pair of side members 47 which are held in spaced relationship by insulating cross-bars 48. In the assembly of frames 45 in the framework 46, the frames are so arranged that cross-bars 48 of the successive frames are laterally staggered relative to the longitudinal axis of the framework so as to provide a zigzag arrangement of conductors 15, as shown in Fig. 11. Thus, in the final assembly, the arrangement of the conductors is the same as that afforded by the supporting structure of Fig. 8 and the ends of the conductors are connected to terminal plates 42, as previously pointed out. With the arrangements of both Figs. 8 and 11, the conductors are maintained in a plurality of groups with the conductors of each group extending in closely spaced zigzag parallel relationship in an imaginary plane surface.

High voltage fuses constructed in accordance with my present invention as hereinbefore set forth are capable of interrupting satisfactorily currents of extremely large magnitude due to the large number of fine wire conductors and the effective zigzag arrangement of the conductors, while at the same time being of very compact, practical, and economical construction. Moreover, as will be evident to one skilled in the art, the invention in certain of its aspects is not limited to the particular details of the exemplary embodiments illustrated, and it is intended, therefore, that the appended claims shall cover such modifications or other applications as do not depart from the true spirit and scope of the invention.

What I claim as new and desire to obtain by Letters Patent of the United States is:

1. In a fuse device including a body of granular, inert, arc-quenching material, a large number of fine wire fusible conductors connected electrically in parallel and extending through and embedded in said material, and an insulating structure for supporting said wires with the wires extending longitudinally of the supporting structure, which said structure engages said wires only at points spaced apart substantial distances along the lengths of the wires in a manner to maintain a longitudinally zigzagging arrangement of the wires and to maintain adjacent ones of the wires substantially uniformly spaced apart at a distance approximately equal to the thickness of a fusion shell formed in said material upon fuse operation in the manner described.

2. In a fuse device including a body of granular, inert, arc-quenching material, a large number of fine wire fusible conductors connected electrically in parallel and extending through and embedded in said material, each of said wires having a diameter in the order of 0.3 mm. or less, and an insulating structure for supporting said wires with the wires extending longitudinally of the supporting structure, which said structure engages the wires only at points spaced apart substantial distances along lengths of the wires

in a manner to maintain the wires in a longitudinally zigzagging arrangement with adjacent ones of the wires substantially uniformly spaced apart at a distance approximately equal to the thickness of a fusion shell formed in said material upon fuse operation in the manner described.

3. In a fuse device including a body of granular arc-quenching material, a large number of fine wire fusible conductors electrically connected in parallel and extending through and embedded in said material, and a structure for supporting said wires with the wires extending longitudinally of the supporting structure, which said structure engages said wires only at points spaced apart substantial distances along the lengths of the wires and in a manner to maintain the wires in a longitudinally zigzagging arrangement in an imaginary regular surface of generation, said elements also being arranged to maintain a substantially uniform spacing in said surface between adjacent ones of said wires.

4. In a fuse device, the combination of a large number of fuse wires, spaced terminal means therefor, an insulating structure supporting said wires with the wires extending generally longitudinally of the supporting structure, which structure includes a plurality of disk-like elements extending transversely of the supporting structure in substantially parallel relationship and located respectively at intervals spaced longitudinally of the supporting structure, said disk-like elements engaging said wires at points spaced apart along the lengths of the wires in a manner to maintain the wires in zigzagging courses with a substantially uniform spacing between adjacent ones of the wires, and granular arc-quenching material surrounding and embedding said wires throughout the major portion of the lengths of the wires.

5. In a fuse device, the combination of a multiplicity of fuse wires, spaced terminal means therefor, an insulating structure supporting said wires with the wires extending generally longitudinally of the supporting structure, which said structure includes a plurality of disk-like elements extending transversely of the supporting structure in substantially parallel relationship and located respectively at intervals spaced apart substantial distances longitudinally of said structure, said disk-like elements having wire engaging means disposed therearound at points spaced from the centers of said elements and engaging said wires at points spaced apart along the lengths of the wires in a manner to maintain the wires in a substantially symmetrical arrangement around the central longitudinal axis of said structure, and a filler of granular arc-quenching material surrounding and embedding the wires throughout the major portion of the lengths of the wires.

6. In a fuse device including a body of granular arc-quenching material and a plurality of fusible conductors extending through and embedded in said material, an insulating structure for supporting said conductors with the conductors extending longitudinally of the supporting structure, which said structure includes a plurality of disks and tubular means extending longitudinally of said structure and substantially centrally of said disks for supporting the disks in spaced relationship longitudinally of said structure with the disks extending transversely of said structure in substantially parallel relationship, said tubular means providing a longitudinal conductor receiving bore and said disks having means therearound at spaced points from the centers of the

disks for engaging said first mentioned longitudinally extending conductors at spaced points along the lengths of the conductors.

7. In a fuse device including a body of granular, arc-quenching material and a plurality of fusible conductors extending through and embedded in said material, an insulating structure for supporting said conductors with the conductors extending longitudinally of the supporting structure, which said structure includes a plurality of individual supporting units joined in end to end relationship, said units including disk-like elements arranged to extend transversely of the longitudinal axis of the supporting structure and spacing elements projecting outwardly substantially from the centers of the disk-like elements and substantially normal to the disk-like elements for joining to the next adjacent ones of the units, and said disk-like elements having conductor receiving means spaced from the centers thereof and arranged to engage said conductors at spaced points along the lengths of the conductors.

8. In a fuse device including a body of granular, arc-quenching material and a plurality of fusible conductors extending through and embedded in said material, an insulating structure for supporting said conductors with the conductors extending longitudinally of the supporting structure, which said structure includes a plurality of disk-like elements and a supporting member extending through substantially centrally located openings in the disk-like elements with tubular spacing members disposed concentrically of said supporting member intermediate adjacent ones of the disk-like elements in longitudinally spaced apart relationship, said disk-like elements having conductor receiving means spaced outwardly from the centers thereof and arranged to engage said conductors at spaced points along the lengths of the conductors.

9. In a fuse device including a body of granular, arc-quenching material and a plurality of fusible conductors extending through and embedded in said material, an insulating structure for supporting said conductors with the conductors extending longitudinally of the supporting structure, which said structure includes a longitudinally extending unitary ladder-like frame comprised of a pair of longitudinally extending side members and a plurality of cross members extending between said side members, which said cross members are disposed in laterally staggered relationship and arranged to be engaged by said longitudinally extending conductors, at spaced points along the lengths of the conductors for effecting relatively sharp changes in direction of the conductors at their points of engagement with said cross members.

10. In a fuse device including a body of granular arc-quenching material and a plurality of fusible conductors extending through and embedded in said material, an insulating structure for supporting said conductors with the conductors extending longitudinally of the supporting structure, which said structure includes a plurality of unitary frames, each comprising a pair of side members having a plurality of cross members extending therebetween in substantially parallel spaced relationship, which said frames are assembled so that the cross members are disposed in laterally spaced relationship both longitudinally and transversely of said supporting structure with

the cross members extending in substantially parallel relationship transversely of the supporting structure, each of said longitudinally extending conductors being successively engaged at spaced points by longitudinally successive ones of said cross members and relatively sharply changing direction at each successive point of engagement in such manner that the conductors have a zig-zag arrangement longitudinally of said supporting structure.

11. In a fuse device including a body of granular arc-quenching material, a plurality of fusible conductors extending in spaced relationship through and embedded in said material, and terminals for said conductors, an insulating supporting structure for the conductors including a plurality of unitary frames, each comprising a pair of side members having a plurality of cross members extending therebetween in spaced apart substantially parallel relationship, which said frames are assembled in substantially parallel juxtaposition so that the cross members of each frame extend in spaced apart substantially parallel relation to the cross members of the respectively adjacent frames, each of said conductors at spaced points along its length engaging certain of said cross members and relatively sharply changing direction at successive points of engagement so as to afford a zig-zag arrangement of the conductors in said supporting structure.

12. In a fuse device including a body of granular arc-quenching material and a plurality of electrically parallel connected fusible conductors extending in spaced relationship through and embedded in said material, an insulating supporting structure for said conductors including a plurality of rows of substantially parallel laterally spaced apart cross members, which said rows are arranged in substantially parallel juxtaposition with the cross members of each row in spaced apart substantially parallel relation to the cross members of the respectively adjacent rows, each of said conductors being arranged to engage at spaced points along its length certain of said cross members and relatively sharply to change its direction at successive points of engagement so that the conductors extend in a zig-zag manner through the supporting structure.

13. In a fuse device, an elongated tubular casing having terminals respectively adjacent the opposite ends thereof, a large number of fuse wires connected electrically in parallel between said terminals and each having greater length than the shortest distance between the terminals, an insulating structure supporting said wires with the wires extending generally longitudinally of said casing and disposed in a substantially symmetrical arrangement around the central longitudinal axis of the casing, said structure comprising a plurality of distinct wire engaging units extending transversely of the casing respectively at intervals spaced longitudinally of the casing, which said units engage said wires only at points spaced apart substantial distances along the lengths of the wires in a manner to maintain the wires in zigzagging courses, and a filler of granular arc-quenching material disposed in the spaces between said units and surrounding and embedding said wires throughout the major portion of the lengths of the wires.

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