Jan. 14, 1947. C. G. SUITS 2,414,344

CURRENT LIMITING FUSE

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Fig. 1.

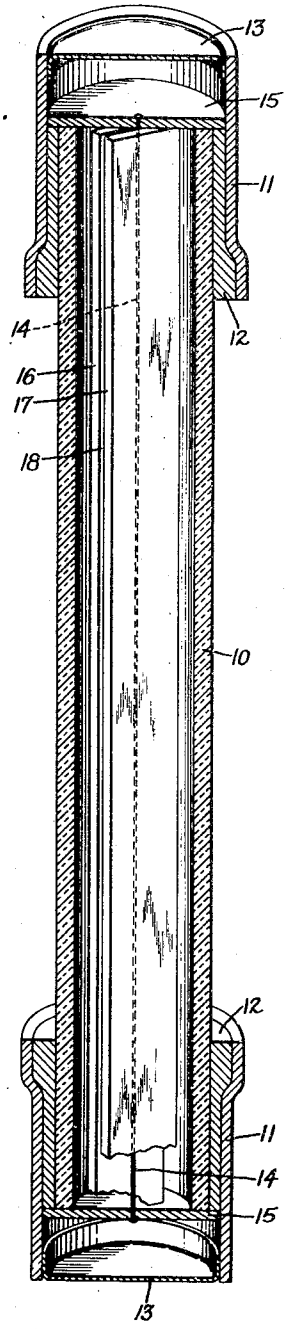


Fig. 2.

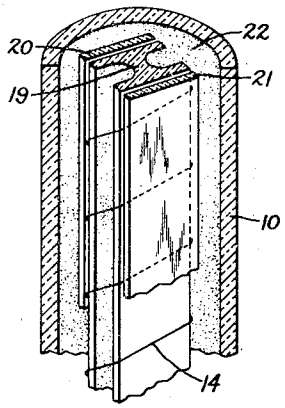
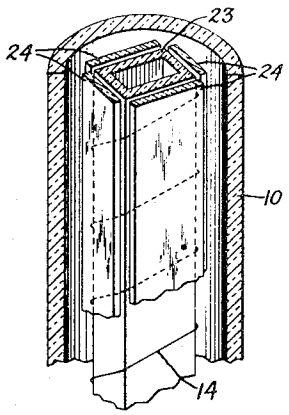


Fig. 3.



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2,414,344

CURRENT LIMITING FUSE

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7 Claims. (Cl. 200—120)

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My invention relates to fuses and more particularly to fuses of the current limiting type.

Current limiting fuses are known which consist in the main of a fusible element in the form of one or more conductors of suitable metal such as silver or zinc embedded in an inert granular or refractory arc-extinguishing material of high dielectric strength such as sand, or relatively finely divided quartz, the conductor or conductors in some instances being wound on a supporting core of high temperature resistant ceramic material. To these parts are added an enclosing housing and terminals for the conductors.

Upon subjection of such fuse to currents of large magnitude, such as upon short circuit, the fusible element attains fusing temperature and dissipates or vaporizes throughout a fusible section of considerable length as distinguished from dissipation only at a point of reduced cross-section, whereupon arcing occurs and the metal vapors rapidly expand to many times the volume originally occupied by the fusible element itself.

The force of this expansion throws the metal vapors out of the arc path and into the spaces between the granules of inert filler material. These vapors condense upon the surfaces of the relatively cool granules and no longer are available for current conduction so that arcing is confined to the small space previously occupied by the fusible element. The intimate physical contact between the hot arc column and the relatively cool granules causes an exceedingly rapid transfer of heat from the arc to the granules resulting in a very high voltage gradient or a high voltage drop per unit length of arc column. The arc energy is dissipated in this heat transfer with practically negligible net pressure within the fuse housing. During the arcing period the granules in the vicinity of the arc melt and upon cooling form a hollow shell or fulgurite consisting of fused quartz if the arc-extinguishing material is granular quartz, and a small percentage of metal from which the fusible conductor is made. This fused shell has the properties of an insulator and in the normal operation of the fuse does not constitute a current-conducting element in the current path.

As a result of the actions referred to in the preceding paragraph there is in effect suddenly inserted into the path of the current at the instant of melting of the fusible element, the high resistance formed by the arc column which initially limits the current to a magnitude which is only a small fraction of the current which the system with which the current limiting fuse is

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associated is capable of producing. The inserted resistance causes rapid current decay and subsequent interruption of the current flow with negligible mechanical disturbance, there being no gassing or discharge of vapors or particles and practically no noise.

I have discovered that if, instead of an arc quenching means comprising an inert granular material, an arc quenching means comprising a pair of flat-spaced surfaces of insulating material such as fused quartz or the like, is used around the fusible element so that the fusible element is mounted between the plates, the current limiting action of the fuse is increased by a relatively large factor. It is my belief that the reason for this higher interrupting ability is based upon the following theory. It should be understood that this theory is presented by way of explanation only and I do not desire to be bound by this theory in the event that it is not the true explanation for the greater interrupting ability of current limiting fuses embodying my invention. It is believed that the space between the flat surfaces forms a reservoir for the hot gases developed by the arc whereby a large amount of the heat developed is removed by conduction and convection from the immediate vicinity of the arc. This action is believed to produce a very satisfactory current limiting action.

It is an object of my invention to provide a new and improved current limiting fuse having a greater current interrupting ability than current limiting fuses known heretofore.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

Referring now to the drawing, Fig. 1 is a cross-sectional view of a current limiting fuse embodying my invention in which the fusible element, for the purpose of simplifying the disclosure, has been shown as a straight conductor extending from end to end of the fuse enclosure and Figs. 2 and 3 are partial views of modifications embodying the teachings of my invention.

The current limiting fuse of Fig. 1 is illustrated as comprising an enclosing tubular casing 10 of insulating material such as fiber or glass upon the opposite ends of which are mounted terminals 11 as by means of a suitable seal 12. If casing 10 is constructed of glass, then 12 is a suitable glass-to-metal seal. The ends of casing 10 are preferably closed by suitable sealing mem-

bers 13 upon which indicia giving information concerning the fuse can be impressed. The fusible element illustrated at 14 is shown simply as a long conductor such as silver or zinc or the like, interconnecting two fuse-supporting members 15 of conducting material which in turn are electrically connected with terminals 11. Fusible element 14 has been illustrated as a single straight conducting member but it should be understood that depending upon the current rating it may comprise one or more parallel conducting members and as will become apparent from the modifications shown in Figs. 2 and 3, it may extend by means of a tortuous path from one end of the enclosing casing 10 to the other. Instead of a silver wire, a flat silver foil might also be advantageously used with my invention as will become apparent from the following description.

The arc quenching means of my invention, which I have found to greatly increase the current interrupting ability and current limiting action of the current limiting fuse of my invention, is illustrated in Fig. 1 as comprising a pair of flat plates 16 and 17 which are mounted in parallel planes along the axis of the fuse casing 10. For highest current limiting action it may be desirable to limit the space 18 between plates 16 and 17 to the diameter of the fusible element 14 so that the plates 16 and 17 are actually pressed against the fusible element. It will be understood that plates 16 and 17 are mounted in this position in any suitable manner as by being suitably clamped between fuse supporting members 15. The volts per centimeter, or voltage gradient, which is indicative of the current limiting action may be decreased somewhat by increasing the spacing 18 between the plates 16 and 17 to a valve somewhat greater than the diameter of the fusible element. With this arrangement the voltage surges produced on the system by virtue of the current limiting action are somewhat reduced but it is believed to be more satisfactory to obtain the highest voltage gradient possible for the maximum current limiting action, by decreasing the spacing 18 to a minimum and using a stepped wire construction, for example, such as is disclosed in Lohausen Patent 2,157,907 to limit the voltage surges produced due to the very high current limiting action. With the arrangement described the arc quenching means of my invention effectively comprises a pair of closely spaced flat surfaces of insulating material arranged to accommodate a fusible element between said surfaces.

The plates 16 and 17 should preferably be constructed from insulating material such as fused quartz, high resistivity glass, fused alumina, opaque fused silica, lava, magnesium oxide, thorium oxide or possibly from other high resistivity ceramics.

Although I have found that the current limiting action of the fuse of Fig. 1 is considerably better than current limiting fuses using an inert granular arc extinguishing filler material, I have found that the addition of such filler material to the disclosure described thus far, operates as satisfactorily as without such filler and under certain cases it may be desirable to include such filler material in the space remaining in casing 10.

Normally it is necessary for the fusible elements in a current limiting fuse to be considerably longer than the practicable length of the casing 10 and it has been customary to support the fusible element on a ceramic member or the like, around which the fusible element is spirally wound. In Figs. 2 and 3 two such constructions are shown which embody the features of the present invention and permit the properties of the flat-plate type of arc extinguishing structure.

Referring now to Fig. 2 I have illustrated a ceramic core 19 which may have an H-cross-section. The fusible element 14 is spirally wound around the ceramic core in the well-known manner. Plates 20 and 21 are then placed adjacent the flat surfaces of the core 19 so as to provide for successive portions of the fusible element the flat plate geometry described in connection with Fig. 1. Flat plates 20 and 21 may be pressed against the flat surfaces of the core 19 if desired, to obtain the highest voltage gradient. It will be understood that with this type of construction mounted in a suitable enclosing casing 10 and embedded in a filler of an inert granular arc extinguishing material such as sand indicated at 22, a sort of a composite current limiting fuse is obtained having the flat plate geometry for a portion thereof and the well-known construction of a fusible element embedded in sand or the like for the other portion. The differential rate of melting of the fusible element between the flat plates as contrasted with the portion thereof embedded in the inert granular material, will provide a means for controlling the surge voltage and maintaining it at a lower value than if the flat plate construction were used throughout.

In Fig. 3 I have disclosed a somewhat similar arrangement to the composite fuse construction of Fig. 2 in which a ceramic core in the form of a hollow square 23 is provided upon which the fusible element comprising one or more parallel conductors is spirally wound. In this case a plurality of flat plates 24 are provided which are respectively mounted adjacent the flat surfaces of the hollow square core 23. With the arrangement disclosed in Fig. 3 a relatively large portion of the fuse would employ the flat plate properties described above as contrasted with Fig. 2.

From the above discussion it will be obvious that I have provided a new and improved current limiting fuse which is simple in construction and which has a higher current interrupting ability and current limiting action than similar fuses used heretofore.

While I have disclosed certain particular embodiments of my invention, it will be apparent to those skilled in the art that my invention is not limited to the particular constructions shown but that changes and modifications may be made without departing from the spirit and scope of my invention and I aim in the appended claims to cover all such changes and modifications.

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

1. In a high tension fuse of the current limiting type, an enclosing casing, an insulating support mounted in said casing, a conductor spirally wound on said insulating support, said insulating support having at least one flat surface, and a flat plate of insulating material disposed adjacent to and parallel with said flat surface to enclose portions of said spirally wound conductor between said flat surface and said flat plate, said conductor being adapted to dissipate throughout a fusible section of considerable length as distinguished from dissipation only at a point of reduced cross section upon subjection of said fusible section to excess current of large magnitude, said flat surface and flat plate providing an arc

quenching means capable of producing a very high voltage gradient upon operation of said fuse so as to exert a high current limiting action.

2. In a high tension fuse of the current limiting type, an enclosing casing, a longitudinally ribbed insulating support mounted in said casing, a conductor spirally wound on said insulating support, said insulating support having a plurality of flat surfaces, and a flat plate of insulating material disposed adjacent to and parallel with each of said flat surfaces to enclose portions of said spirally wound conductor between said flat plates and flat surfaces, said conductor being adapted to dissipate throughout a fusible section of considerable length as distinguished from dissipation only at a point of reduced cross section upon subjection of said fusible section to excess current of large magnitude, said flat surfaces providing an arc quenching means, capable of producing a very high voltage gradient upon operation of said fuse so as to exert a high current limiting action.

3. In a high tension fuse of the current limiting type comprising an enclosing casing, a longitudinally ribbed H-shaped insulating support having two flat surfaces mounted in said casing, a conductor spirally wound on said insulating support, said conductor being adapted to dissipate throughout a fusible section of considerable length as distinguished from dissipation only at a point of reduced cross section upon subjection of said fusible section to excess current of large magnitude, and a flat plate of insulating material associated with each of the flat surfaces of said insulating support disposed adjacent to and parallel with said flat surfaces to enclose portions of said spirally wound conductor between said flat surfaces and said flat plates, said flat surfaces and plates providing an arc quenching means capable of producing a very high voltage gradient upon operation of said fuse so as to exert a high current limiting action.

4. In a high tension fuse of the current limiting type comprising an enclosing casing, an insulating support in the shape of a hollow square having a plurality of flat surfaces mounted in said casing, a conductor spirally wound on said insulating support, said conductor being adapted to dissipate throughout a fusible section of considerable length as distinguished from dissipation only at a point of reduced cross section upon subjection of said fusible section to excess current of large magnitude, and a plurality of flat plates of insulating material one associated with each of the flat surfaces of said insulating support and disposed adjacent to and parallel with said flat surfaces to enclose portions of said spirally wound conductor between said flat surfaces and said flat plates.

5. In a high tension fuse of the current limiting type, an enclosing casing, an insulating support having at least one flat surface mounted in said casing, a conductor spirally wound on said insulating support said conductor being adapted to dissipate throughout a fusible section of considerable length as distinguished from dissipation only at a point of reduced cross section upon subjection of said fusible section to excess current of large magnitude, a flat plate of insulating material disposed adjacent to and parallel with said flat surface to enclose portions of said spirally wound conductor between said flat surface and said flat plate, and an inert granular arc extinguishing material in said casing embedding the portions of said spirally wound conductor not enclosed between said flat surface and said flat plate.

6. A high tension fuse of the current limiting type including in combination a cylindrical casing of insulating material, a conductor mounted within said casing and adapted to dissipate throughout a fusible section of considerable length as distinguished from dissipation only at a point of reduced cross-section upon subjection of the fusible section to excess current of large magnitude, and arc quenching means comprising two members of insulating material mounted within said casing so as to extend longitudinally thereof, each of said members having a flat surface extending throughout substantially the whole length of said casing and said members being positioned in said casing with said flat surfaces on opposite sides of and adjacent the conductor whereby to exert a high current limiting action upon subjection of said conductor to excess current of large magnitude.

7. A high tension fuse of the current limiting type including in combination a cylindrical casing of insulating material, two terminals respectively mounted at the ends of said casing, two fuse supports respectively mounted at the ends of said casing in current conducting relationship with the terminals at the respective ends, a conductor mounted within said casing and interconnecting said fuse supports, said conductor being adapted to dissipate throughout a fusible section of considerable length as distinguished from dissipation only at a point of reduced cross-section upon subjection of the fusible section to excess current of large magnitude, and arc quenching means comprising two members of fused quartz mounted within said casing so as to extend longitudinally thereof, each of said members having a flat surface extending from one of said fuse supports to the other and said members being positioned with said flat surfaces closely spaced and pressing against the fusible section of said conductor from opposite sides thereof whereby to exert a high current limiting action upon subjection of the conductor to excess current of large magnitude.

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