Jan. 19, 1943. H. L. RAWLINS ET AL 2,309,013

CURRENT LIMITING FUSE

Filed Sept. 19, 1940

Fig. 1.

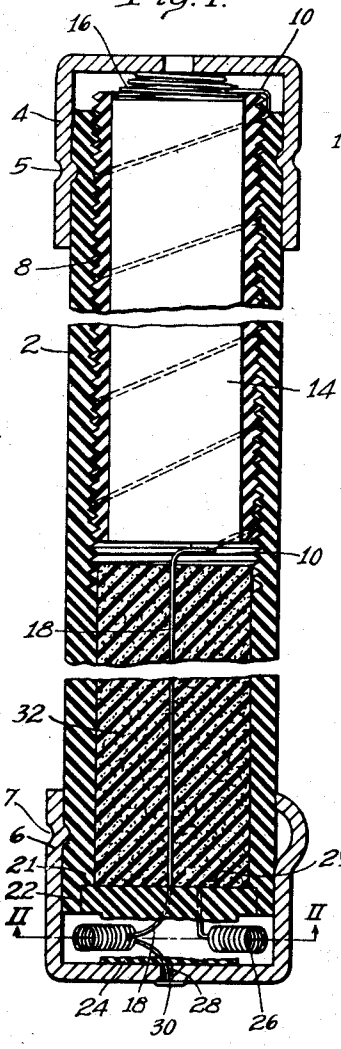


Fig. 4.

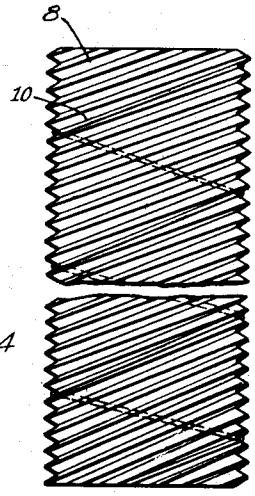


Fig. 3.

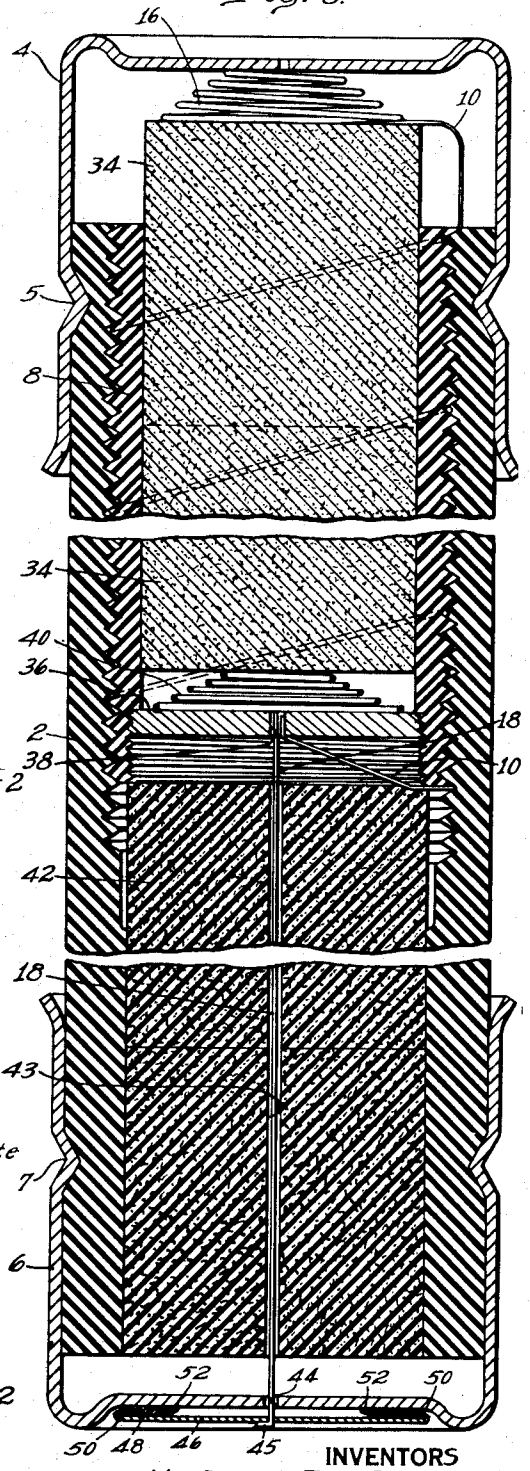
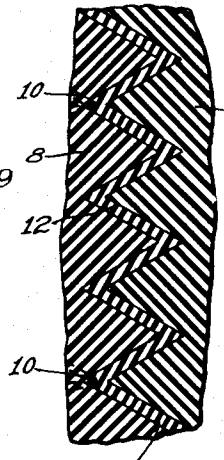


Fig. 5.



Cellulose Acetate Solution

Fig. 2.

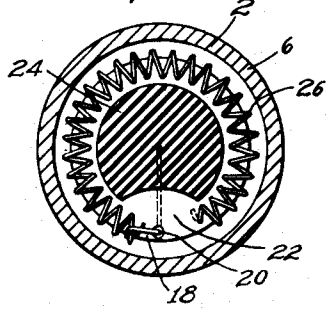
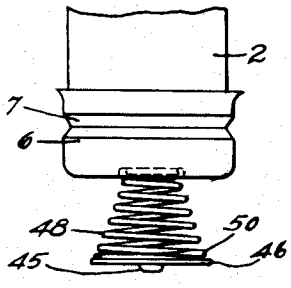


Fig. 6.



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CURRENT LIMITING FUSE

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Application September 19, 1940, Serial No. 357,394

17 Claims. (Cl. 200—120)

This invention relates generally to circuit interrupters, and more specifically to interrupters which are capable of automatically interrupting a circuit in response to the passage therethrough of currents above a predetermined value, and at the same time limit the value of the current interrupted. The invention will be more particularly disclosed in connection with a fuse which is capable of limiting the current when the fuse blows.

This invention relates especially to a current limiting interrupter or fuse of the type where an arc establishing means such as a fusible means is provided in shunt relation with respect to a current limiting means, and is confined so that the arc formed upon operation of the arc establishing means has a high arc voltage so as to quickly transfer the current to the current limiting means. The current thus limited is easily interrupted by a circuit interrupting means which may be a second fusible means.

Current limiting means of this general type are disclosed in the copending applications of H. L. Rawlins, Serial No. 357,393, filed September 19, 1940, and A. P. Strom, Serial No. 357,395, filed September 19, 1940, and both assigned to the same assignee of this invention. The instant invention relates to certain improved constructions of current limiting interrupters, and one object of the invention is to provide in an interrupter of the type described, novel means for restricting an arc to provide for a high arc voltage.

A further object of this invention is to provide a novel means for supporting a fuse wire in a closely confined arc passage having walls of an insulating material.

Another object of this invention is to provide a novel means for sealing a fuse wire in a closely restricted fuse passage.

Another object of this invention is to provide a novel arrangement and construction of a current limiting fuse of the type described which is particularly efficient in operation, relatively simple in design and economical to manufacture.

These and other objects of this invention will become more apparent upon consideration of the following detailed description of preferred embodiments thereof, taken in connection with the attached drawing in which:

Figure 1 is a substantially central longitudinal section view of a current limiting fuse constructed in accordance with the invention.

Fig. 2 is a transverse sectional view taken substantially on the line II—II of Fig. 1.

Fig. 3 is a central, longitudinal sectional view of a modified form of fuse constructed in accordance with this invention.

Fig. 4 is an elevational view of an inner portion of the fuse shown in Figs. 1 and 2.

Fig. 5 is an enlarged fragmentary sectional view of threadedly engaging portions of the fuse shown in Fig. 1, and

Fig. 6 is a partial elevational view of the lower end of the fuse shown in Fig. 3, with the indicator shown in an indicating position.

Referring first to the embodiment of the invention shown in Fig. 1, the fuse there illustrated comprises an outer insulating fuse tube 2 which may be of any desired insulating material, such, for example, as fiber or a synthetic resin, or a like material which has the property of being capable of evolving an arc extinguishing gas when in proximity to an electric arc. The fuse tube 2 is provided with end terminal caps 4 and 6, respectively, at the opposite ends thereof, and these caps may be secured to the fuse tube 2 in any desired manner, such, for example, as by depressing a portion 5, 7 of the cap flanges inwardly into the material of the fuse tube 2.

Referring to Fig. 4 of the drawing, there is illustrated an inner insulating tubular sleeve 8 having a threaded exterior surface designed to be threadedly engaged with the threads provided on the interior wall at the upper end of fuse tube 2. It will be noted that the threads both on inner tube 8 and outer fuse tube 2 are multiple threads, and, as shown in the drawing, are eight-lead threads. Before the inner insulating tube 8 is assembled in the outer fuse tube 2, however, a fuse wire 10 is wound in at least one of the threads of the inner tube 8 as shown in Fig. 4. The fuse wire 10 is preferably of a material having a high temperature melting point, such, for example, as silver, and although the fuse wire 10 is shown as being laid in only one thread of the multiple threads of inner tube 8, obviously for fuses of higher capacity, parallel fuse wires may be laid in one or more intermediate threads of inner tube 8. After the fuse wire 10 is wound in a thread of inner tube 8, the wire and tube are then coated with a viscous paint 12 (Fig. 5) constituting a solution of some material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc and a solvent therefor, such, for example, as cellulose acetate or ethyl cellulose solution. The inner tube 8, together with fuse wire 10 and coating 12 may then be threaded into fuse tube 2 to the position shown in Fig. 1 of the drawing. By referring to Fig. 5, the manner in which the coating 12 seals fuse wire 10 in the base of a thread on inner tube 8, and also the manner in which coating 12 seals the thread in which fuse wire 10 is laid, from adjacent threads, is clearly indicated.

This particular structure described above for supporting a fuse wire 10, entirely seals the wire so that it is confined by gas evolving insulating material and is also insulated between

the turns thereof, so that when the fuse wire melts on currents above a predetermined value the arc path will be quite long compared to the length of inner tube 8, and will be restricted to the very small passage occupied by wire 10, so that the arc has a very high resistance and a high arc voltage, all for a purpose to be hereinafter described. The coating material 12 not only provides the small arc passage when fuse wire 10 melts, but also insulates adjacent turns of the wire from each other to prevent flashovers between turns, and this is also further inhibited by the tortuous path between turns of the fuse wire due to the multiple thread construction of fuse tube 2 and inner tube 8.

Inside inner tube 8 there is provided a current limiting means 14 in the form of a resistor block preferably of a non-metallic resistance material such as carbon or carborundum. Such a resistor should preferably be in the form of finely divided resistance particles bonded together to have a valve action to reduce the resistance thereof above a predetermined safe voltage, and accordingly may be of the same type and operate in the same manner as the current limiting resistors disclosed in said copending application of A. P. Strom. The block 14 is preferably secured in inner tube 8 by cementing the same in position, and a coil compression spring of conducting material 16 is provided between the upper end of the resistor block 14 and end cap 4, to conduct current from the end cap to the upper end of the resistor block. It will also be noted that the upper end of fuse wire 10 is soldered to coil spring 16, to thereby connect one end of the fuse wire 10 to terminal cap 4. The other end of fuse wire 10 is soldered to a fuse wire 18, which extends below inner tube 8 downwardly, through the fuse tube 2 and through an aperture 20 in an insulating closure disk 22 for the lower end of fuse tube 2. Fuse wire 18 has different melting characteristics than fuse wire 10 and should melt on lower currents than fuse wire 10, and for this purpose may be of a silver or copper alloy, for example. The insulating closure disk 22 for the lower end of the fuse tube is provided with an integral reduced extension 24 which engages terminal cap 6 to maintain the closure disk 22 in operative position against shoulder 21 formed on the fuse tube. The extension 24 serves to support an enlongated coil tension spring 26 which has one end thereof angularly extended through an aperture in disk 22 to be bent over as at 29, on the opposite side of the disk to thereby anchor this end of the spring to the disk. The other end of the coil spring is pulled out or tensioned, and fuse wire 18 is passed through an end coil of the spring and extends through aperture 28 in end cap 6 to be secured therein as at 30, by soldering or the like. Fuse tube 2 contains a filling of powder 32, about fuse wire 18, and this powder 32 may be of any desired arc extinguishing material but is preferably of a material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc, such, for example, as boric acid, gypsum or the like.

In the operation of the fuse shown in Figs. 1, 2, 4 and 5, upon the occurrence of a short circuit, fuse wire 18 melts first, since it has a lower melting point than fuse wire 10. However, fuse wire 10 also melts substantially immediately thereafter because although it has a higher melting point than fuse wire 18, its melting point is much below that of normal short circuit currents. When fuse wire 10 melts an arc is thereby established in the very small arc passage between the threads of fuse tube 2 and inner tube 8 which, as previously described, has a very high arc voltage. The value of resistor 14 is related to the arc voltage which will be produced in the passage between tubes 2 and 8 so that substantially as soon as arc voltage appears across the passage in which fuse wire 10 lies, the current will be very quickly transferred to the resistor which will act to limit the current, and the current thus limited will be easily interrupted at the next current zero by the arc extinguishing material 32 in the lower fuse chamber. When a resistor having valve characteristics is employed; it will also act to limit the voltage to a predetermined safe value.

The manner in which fuse wire 10 is mounted is of importance because this mounting, while being relatively simple to assemble, is extremely effective in providing a high resistance path for an arc when the fuse blows, and consequently a high arc voltage, which is essential for obtaining a quick transfer of the current from this passage to the resistor. This current transfer should occur in a small fraction of a half cycle before the short circuit current has had a chance to build up to any dangerously high value. With the construction illustrated, the current may be transferred from the spiral path between fuse tube 2 and inner tube 8 in approximately one-tenth of a cycle depending, of course, upon the available current. Such speed in transfer is also very desirable in order to limit the current which it is necessary to interrupt with arc extinguishing material 32. Obviously, if this current can be kept small, it can be easily interrupted entirely within a small interrupting chamber. It should also be noted that the spring 26 tensioning fuse wire 18 is positioned in such a manner that it occupies but a relatively insignificant portion of the overall length of the fuse, while at the same time it is capable of moving the unfused terminal of the fuse wire a much longer distance.

Referring now to the embodiment of the invention shown in Figs. 3 and 6, inasmuch as many of the parts of the fuse shown in these figures are identical with those already described in connection with the embodiment of the invention shown in Figs. 1, 2, 4 and 5, like reference numerals are used to designate such like parts, and to avoid repetition these parts will not be again described in detail. The current limiting means in this embodiment of the invention comprises a pair of blocks 34 of resistance material similar to the material constituting the resistor 14 previously described. The resistor blocks 34 are not secured in inner tube 8, but are slidably mounted therein. The fuse shown in Figs. 3 and 6 is essentially a higher voltage fuse than that shown in Fig. 1 and accordingly must have a greater length which enables the use of a longer length of resistor material and thereby cuts down the heating effect thereof. A conducting metal partition disk 36 is threadedly engaged in the lower end of inner tube 8 as shown in Fig. 3, and this partition disk is provided with a substantially central aperture 38 for receiving the lower end of fuse wire 18 and the upper end of fuse wire 18 to be secured therein, for example, as by soldering or the like. A coil compression spring 40 is provided between partition disk 36 and lower resistor block 34 which, in cooperation with spring 16, maintains a good electrical con-

tact between terminal cap 4, resistors 34 and partition disk 36. Instead of utilizing powdered arc extinguishing material, such as the material 32 described in connection with the embodiment of the invention shown in Fig. 1, it is preferred to use blocks 42 which may be of the same material as the material 32 previously referred to, but compressed or otherwise formed into blocks with a passage 43 extending substantially centrally through each block to receive fuse wire 18. It will be noted that in this embodiment of the invention fuse wire 18 extends downwardly through an aperture 44 in end cap 6 and through an aperture in an indicating disk 46, to be bent over and secured to the disk as at 45, by solder or the like.

A spiral compression coil spring 48 is provided between indicating disk 46 and end cap 6, with the outer coil 50 of the spring secured to indicating disk 46, for example, as by soldering or the like; and the inner coil 52 of the spring is secured to end cap 6 in a like manner. As shown in Fig. 3, normally fuse wire 18 maintains spring 48 in a compressed condition so that the indicating disk 46 lies closely adjacent the end cap 6.

The operation of this embodiment of the invention is substantially identical with that of the embodiment of the invention illustrated in Figs. 1, 2, 4 and 5, of the drawing, and therefore it will not be again specified in detail to avoid repetition. On short circuits, both fuse wires 18 and 10 will blow as before, the current will be shifted to resistor blocks 34, and finally interrupted in bores 43 through blocks 42. Obviously as soon as fuse wire 18 melts, coil spring 48 will not only act to withdraw any lower unfused portion thereof, but will also act to move indicating disk 46 to a projecting position with respect to the terminal cap 6 to thereby provide a readily visible indication that the fuse has blown. This position of the indicating disk 46 is shown in Fig. 6 of the drawing.

As previously stated, fuse wire 18 melts on lower currents than fuse wire 10, with fuse wire 18 preferably being of a size to interrupt currents according to the rating of the fuse and may, for example, be fusible on currents of 1 or 2 amperes, whereas fuse wire 10 need not blow until the current exceeds a value above which it is desirable to limit the current in order to prevent damage to circuits and apparatus served thereby, and therefore fuse wire 10 may, for example, not fuse until currents reach a relatively high value such, for example, as 80 amperes. From this illustration, it is obvious that when fuse wire 18 blows on relatively small currents, that is, in the illustration given, currents less than 80 amperes, fuse wire 10 need not blow at all inasmuch as these currents can be easily interrupted by fuse wire 18 due to elongation of the arc formed by coil spring 26 of the embodiment shown in Fig. 1, and spring 48 in the embodiment shown in Fig. 3, along the arc extinguishing material 32 or 42, to thereby increase the arc voltage by elongation of the arc, and evolution of arc extinguishing gas in the path of the arc will extinguish the arc. Such a method of extinguishing an arc, if limited to low current arcs, can be carried out by means assembled in a relatively small space, and, accordingly, the structures illustrated, since they will never be called upon to interrupt large amounts of current due to the efficient current limiting action thereof, can be made of relatively simple and compact construction as illustrated.

In the foregoing there has been disclosed modifications of a novel type of current limiting fuse having novel means for mounting a shunt fuse for a current limiting resistor means, to obtain exceptionally quick transfer of the current from the shunt path to the resistor. A novel arrangement of parts in a fuse including a resistor and shunt and series fuses has also been disclosed, together with novel biasing means for the series fuse which may also include an indicating means for indicating the condition of the fuse.

Having particularly described preferred embodiments of the invention as provided in the patent statutes, it should be understood that the invention is not to be limited to the specific embodiments herein disclosed, inasmuch as it will be obvious, particularly to persons skilled in the art, that many changes and modifications may be made in these particular constructions without departing from the broad spirit and scope of this invention. Accordingly it is desired that the invention be interpreted as broadly as possible and that it be limited only by the prior art and by what is expressly stated in the following claims.

We claim as our invention:

1. In a circuit interrupter, a pair of telescoping loosely threadedly engageable members of insulating material with the thread on each of said members comprising a multiple thread so as to provide a plurality of separate, restricted spiral arc passages at the bases of the threads on at least one of said members, and means for striking an arc in one of said arc passages, whereby the intermediate threads provide a tortuous path between successive turns of said one passage.

2. In a circuit interrupter, a pair of telescoping loosely threadedly engageable members of insulating material with the thread on each member substantially entirely filling the thread groove on the other member so as to form a restricted spiral arc passage at the base of a thread on at least one of said members, a fusible wire positioned in said passage, and means of insulating material for sealing said wire in said passage and for sealing off adjacent turns of said passage to further restrict said arc passage and to prevent flashover between the turns thereof.

3. In a circuit interrupter, means of insulating material having a surface provided with a plurality of spaced, substantially parallel continuous grooves therein to form arc passages, a second means of insulating material having a surface contiguous with respect to said grooved surface, and having a plurality of correspondingly spaced and parallel continuous projections adapted to substantially fill said grooves to restrict said arc passages with said members maintained in substantially fixed relation, and means for striking an arc in certain of said passages, with at least one other passage between said certain passages to provide a tortuous path therebetween.

4. In a circuit interrupter, a pair of telescoping loosely threadedly engageable members of insulating material adapted to form a restricted spiral arc passage at the base of a thread on at least one of said members, a fusible wire positioned in said passage, and means of insulating material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc for sealing said wire in said passage and for sealing off adjacent turns of said passage to further restrict said arc passage and to prevent flashover between the turns thereof.

5. In a circuit interrupter, means of insulating material having a surface provided with a con-

tinuous groove therein to form an arc passage, a second means of insulating material having a surface contiguous with respect to said grooved surface, and having a continuous projection adapted to substantially fill said groove to restrict said arc passage with said members maintained in substantially fixed relation, means for striking an arc in said passage, and means of a material capable of evolving an arc extinguishing gas when in proximity to an electric arc for sealing said passage.

6. In a circuit interrupter, a pair of loosely threadedly engaged, telescoping tubes of insulation material, adapted to form a restricted spiral arc passage at the base of a thread on at least one of said members, means for striking an arc in said arc passage, and current limiting means located in the inner one of said tubes and connected in parallel relation with said means for striking an arc.

7. In a fuse, a fuse tube having terminals adjacent opposite ends thereof, an inner tube telescopically engaging at least a portion of the inner wall of said fuse tube, at least one of said tubes having a shallow spiral groove on the surface confronting the other tube to form a restricted spiral arc passage, current limiting means in said inner tube, a fuse wire positioned in said passage, and shunting said current limiting means, and means connecting said current limiting means and fuse wire between said terminals.

8. In a fuse, a fuse tube having terminals adjacent opposite ends thereof, an inner tube telescopically engaging at least a portion of the inner wall of said fuse tube, at least one of said tubes having a shallow spiral groove on the surface confronting the other tube to form a restricted spiral arc passage, current limiting means in said inner tube, a fuse wire positioned in said passage and shunting said current limiting means, and means connecting said current limiting means and fuse wire between said terminals including fusible means.

9. In a fuse, a fuse tube having end terminal closure means at opposite ends thereof, transverse terminal partition means in said tube intermediate the ends thereof to form a pair of chambers, current limiting means in one of said chambers, resilient means for maintaining said current limiting means in engagement with at least one of said terminal means, shunt fusible means for said current limiting means, and series fuse means connecting said current limiting means to another of said terminal means.

10. In a fuse, a fuse tube having terminals adjacent opposite ends thereof, current limiting means and shunt fusible means therefor connected to one of said terminals, series fusible means connecting said current limiting means and shunt fusible means to the other of said terminals, and means biasing said series fusible means to separate the ends thereof when said series fusible means fuses.

11. In a fuse, a fuse tube having terminals adjacent opposite ends thereof, current limiting means and shunt fusible means therefor connected to one of said terminals, series fusible means connecting said current limiting means and shunt fusible means to the other of said terminals, means biasing said series fusible means to separate the ends thereof when said series fusible means fuses, and indicating means movable to a projecting position with respect to said fuse tube by said biasing means when the fuse blows.

12. In a circuit interrupter, means of insulating material having a surface provided with a continuous groove therein to form an arc passage, a second means of insulating material having a surface contiguous with respect to said grooved surface to cover said groove, a fuse wire in said groove, and means of an insulating adhesive material in said groove for sealing said wire therein and securing said insulating means together.

13. In a circuit interrupter, a pair of telescoping loosely threadedly engageable members of insulating material adapted to form a restricted spiral arc passage at the base of a thread on at least one of said members, a fusible wire positioned in said pasage, and means of an insulating adhesive material for sealing said wire in said passage, sealing off adjacent turns of said passage to further restrict said arc passage and to prevent flashover between the turns thereof, and for securing said members together.

14. In a circuit interrupter, a pair of telescoping tubes of insulation material, at least one of said tubes having a shallow spiral groove on the surface confronting the other tube to form a restricted spiral arc passage, means for striking an arc in said arc passage, and current limiting means located in the inner one of said tubes and connected in parallel relation with said means for striking an arc.

15. In a fuse, a fuse tube having end terminal closure means at opposite ends thereof, transverse terminal partition means in said tube intermediate the ends thereof to form a pair of chambers, current limiting means in one of said chambers, resilient means for maintaining said current limiting means in engagement with at least one of said terminal means, shunt fusible means for said current limiting means, and series fuse means in the other of said chambers connecting said current limiting means to another of said terminal means.

16. In a fuse, a fuse tube having terminals adjacent opposite ends thereof, an inner tube telescopically engaging at least a portion of the inner wall of said fuse tube, at least said inner tube having a shallow substantially spiral groove on the periphery thereof to form with said fuse tube a restricted substantially spiral arc passage, current limiting means in said inner tube, a fuse wire positioned in said passage in shunt relation with said current limiting means, and means connecting said current limiting means and fuse wire between said terminals.

17. In a fuse, a fuse tube having terminals adjacent opposite ends thereof, current limiting means and shunt fusible means therefor connected to one of said terminals, series fusible means connecting said current limiting means and shunt fusible means to the other of said terminals, said shunt fusible means having a higher melting point than said series fusible means, and means biasing said series fusible means to separate the ends thereof when said series fusible means fuses.

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