United States Patent

McKeithan

[15] **3,648,211**

[45] **Mar. 7, 1972**

[54] HIGH-VOLTAGE CURRENT LIMITING PROTECTIVE DEVICE

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[22] Filed: **Dec. 10, 1969**

[21] Appl. No.: **883,951**

[52] **U.S. Cl.**.....**337/202,** 337/159, 337/246

[51] **Int. Cl.**.....**H01h 85/02,** H01h 85/48

[58] **Field of Search**.....337/161, 166, 168, 186, 187, 337/201, 202, 204, 208, 209, 222, 224, 227, 228, 231, 245, 246, 159, 293, 295

[56] **References Cited**

UNITED STATES PATENTS

3,243,552	3/1966	Mikulecky	337/293 X
3,345,483	10/1967	Leonard et al	337/202 X
3,309,477	3/1967	Bronikowski	337/202 X
2,523,139	9/1950	Owens	337/231 X
2,108,993	2/1938	Ramsey	337/202
1,730,716	10/1929	Austin	337/224 X
3,345,483	10/1967	Leonard et al	337/202 X

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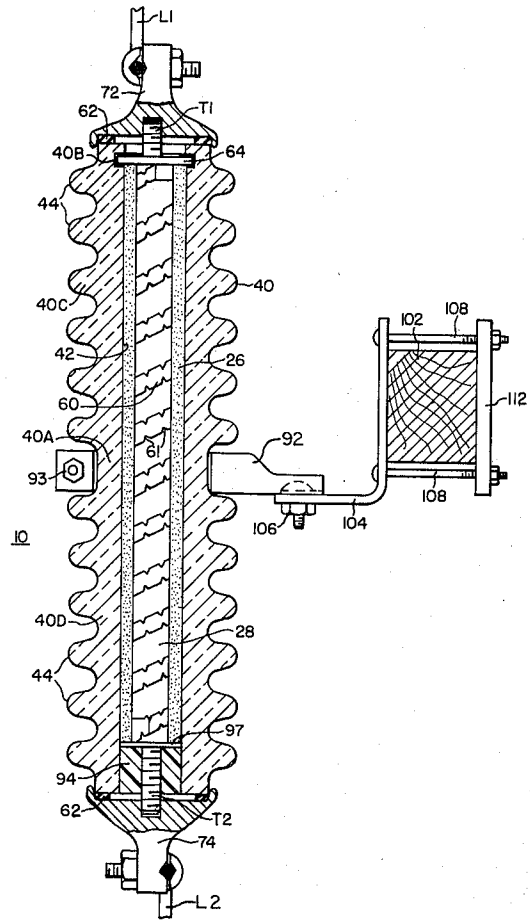
[57] **ABSTRACT**

A high-voltage protective device comprising a hollow, generally cylindrical, electrically insulating member having an inner bore. A pair of terminal members is mounted on the insulating member adjacent to the opposite ends. One or more fuse links or fusible elements is disposed in the inner bore and spaced therefrom with each fuse link being connected between the associated terminal members. A finely divided or pulverulent arc quenching material substantially fills the space between each fuse link and the inner bore of the associated insulating member. A supporting means is secured to said insulating member at only one location which is axially intermediate the ends of said insulating member.

10 Claims, 1 Drawing Figure



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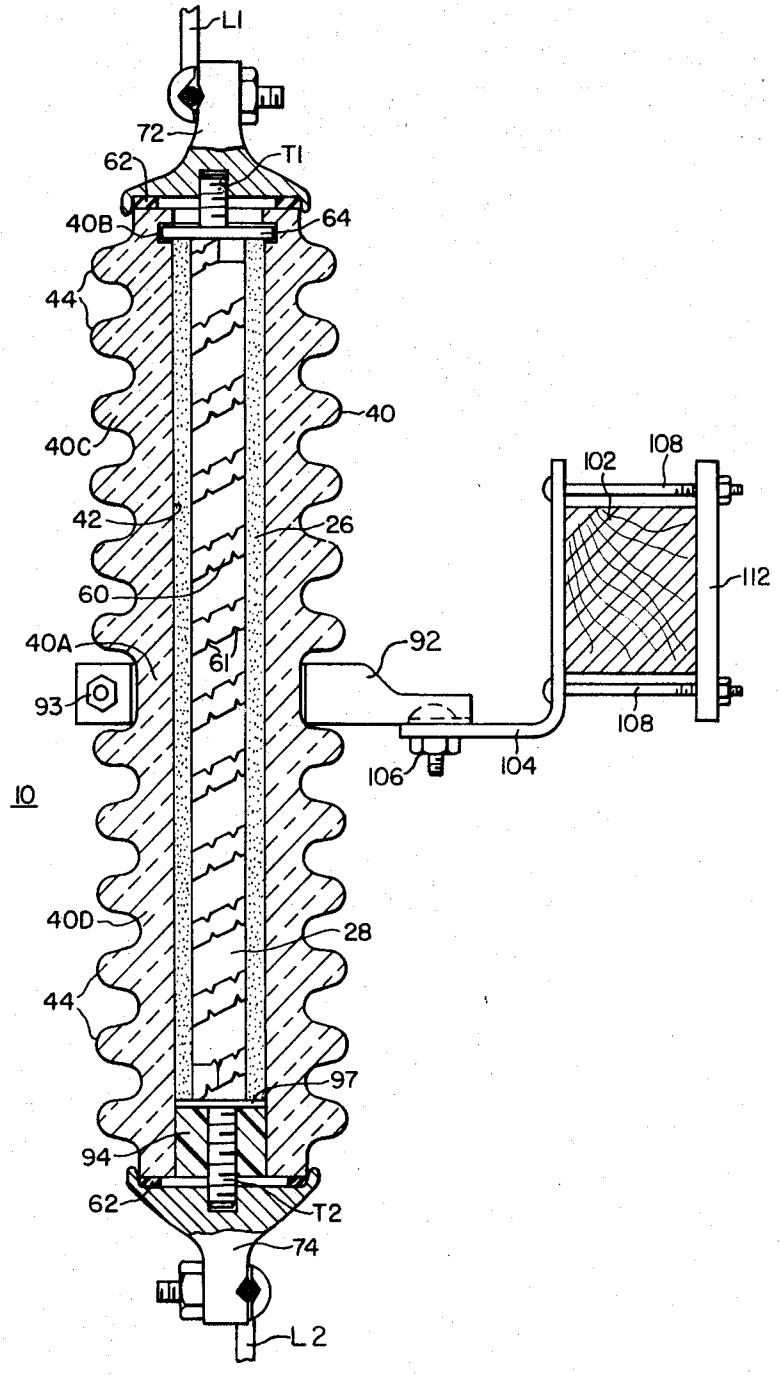

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HIGH-VOLTAGE CURRENT LIMITING PROTECTIVE DEVICE

CROSS REFERENCES TO RELATED APPLICATIONS

Certain subject matter disclosed in the present application is also disclosed and claimed in copending application Ser. No. 883,911 filed concurrently by Wesley L. McKeithan and John J. Astleford and assigned to the same assignee as the present application.

BACKGROUND OF THE INVENTION

This invention relates to high voltage protective devices, and, more particularly, to high voltage power fuse structures.

In the mounting or supporting of high voltage protective devices, such as power fuses, it is common practice to support each fuse at the opposite ends or terminals of the fuse structure by means of a pair of spaced insulator supports having contact means or clips disposed thereon. The insulator supports in such an arrangement are normally mounted on a base which, in turn, must be supported on a suitable supporting structure. The electrical insulation required in such an arrangement between each terminal of the power fuse which is normally maintained at a relatively high potential and the adjacent metallic supporting members, which are normally formed from an electrically connecting material and which may be at ground or zero potential, is provided by the usual insulators supports.

Such known mounting structures for high voltage power fuses have certain disadvantages with respect to the required structural members involved in a particular application and the overall space required for the mounting of each power fuse. It is therefore desirable to provide an improved construction for such protective devices which overcomes certain of the above disadvantages.

SUMMARY OF THE INVENTION

In accordance with the invention, a protective device comprises a hollow, generally cylindrical, electrically insulating member or bushing having an inner bore extending axially therethrough. A pair of terminal members is mounted adjacent to the opposite ends of the insulating member with each terminal member having secured thereto means, more specifically solderless type connectors, for connecting external electrical conductors or cables to the opposite ends of the overall protective device. One or more fusible elements or fuse links is disposed in and laterally spaced from the inner bore of the insulating member. The space between each fusible element and the inner bore of the insulating member is substantially filled with a finely divided or pulverulent or granular arc quenching material which is disposed in heat transferring relation with each fusible element and the inner bore of the insulating member. Where desired, an elongated supporting member formed from electrically insulating material, which may also be gas evolving during the operation of the protective device, may also be disposed in and spaced from the inner bore of the insulating member to extend axially between the associated terminal members and to support each fusible element. In order to support the overall protective device, only one supporting bracket or member is secured to a portion of the insulating member which is axially intermediate the ends of the insulating member, preferably at approximately the midpoint or middle portion of the insulating member. The insulating member also preferably includes a plurality of axially spaced, outwardly projecting portions or petticoats between the portion of the insulating member to which the supporting member is secured and both ends of the insulating member to increase the electrical creepage insulating path or distance between each terminal member and the associated supporting bracket of the protective device which may be formed from an electrically conducting material and for other purposes as well.

It is therefore an object of this invention to provide an improved elongated, high voltage protective device which is uniquely adapted to be supported at only one location along its overall length.

BRIEF DESCRIPTION OF THE DRAWING

Other objects of the invention will be apparent from the following detailed description taken in conjunction with the accompanying drawing in which the single FIGURE is a view, partly in side elevation and partly in section, of a protective device embodying the principal features of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, there is illustrated a protective device or high voltage current limiting fuse structure **10** embodying the teachings of the invention. In general, the protective device **10** is elongated in configuration and is adapted to be supported at only a single location along its overall length.

More specifically, the protective device **10** includes a hollow, generally cylindrical, electrically insulating member or bushing **40** having an axially extending inner bore, as indicated at **42**. The electrically insulating member **40** may be formed from a suitable insulating material of the ceramic type, such as porcelain, or may be cast or molded from a thermosetting resin, such as an epoxy or polyester resin, or from an elastomeric material, such as butyl rubber, in either of the latter materials with a suitable filler, such as aluminum trihydrate for antitracking characteristics.

In order to support the protective device **10**, more specifically, the electrically insulating member **40** at only a single location which is axially intermediate or spaced from both ends of the insulating member **40**, the insulating member **40** includes at its outer periphery a portion **40A** which is located axially intermediate the ends of said insulating member and which is preferably located at approximately the midpoint of the insulating member **40** or comprises the axially middle portion of said insulating member. The middle portion **40A** of the insulating member **40** is adapted to receive an associated supporting means or bracket member **92** which is secured to the insulating member **40** by suitable means, such as the bolt indicated at **93** in the drawing. The bracket or support member **92**, in turn, is secured to a suitable supporting means, such as the angle member **104**, by suitable means such as the bolt **106**. The angle member **104** may, in turn, be secured to a supporting structure, such as the wooden crossarm **102** of a utility pole, by suitable means such as the backplate **112** and the bolts **108** which pass through aligned openings in the angle member **104** and the backplate **112**. Alternatively, the bracket member **92** may be secured to a supporting steel structure in a substation installation.

The insulating member **40** also includes a plurality of axially spaced, outwardly projecting portions or petticoats **44** between the middle portion **40A** and each end of the insulating member **40** to increase the electrically insulating creepage path or distance between the support or bracket member **92** which may be formed from a metallic material which is also electrically conducting, such as steel, and each end of the insulating member **40**, and to increase the heat radiating capability of the insulating member **40** considered as a thermal mass in the operation of the protective device **10**, as will be explained in greater detail hereinafter.

In order to facilitate the assembly of an upper terminal member T1 as shown in the drawing, the upper end of the insulating member **40** includes a recess which extends around the inner bore **42** and which includes a radial slot **40B** which is adapted to receive a cross pin **64** which is secured to or formed integrally with the terminal member T1. The cross pin **64** prevents rotation of the terminal member T1 and certain associated parts which will be described hereinafter after such parts are assembled with the insulating member **40**. The upper terminal member T1 may be formed from any suitable electrically conducting material, such as copper, and, as illustrated, includes an externally threaded portion which projects or ex-

tends axially from the upper end of the insulating member **40**. A solderless type connector **72** may be secured to the upper terminal member **T1** by screwing an internally threaded portion of the connector **72** on the axially extending, threaded portion of the upper terminal member **T1**, as shown in the drawing. The connector **72** may include an overhanging portion which seats against the upper end of the insulating member **40** and closes off the inner bore of the insulating member **40** at the upper end of said insulating member. As shown in the drawing, the connector **72** includes an adjustable threaded member to permit electrical connections to the protective device **10** from an external source of electrical power or alternating current voltage as indicated by the conductor **L1**. In order to seal off the upper end of insulating member **40**, a gasket member **62** may be disposed between an overhanging portion of the connector **72** and the upper end of insulating member **40** and compressed when the connector **72** is tightened down on the upper terminal member **T1**.

In order to permit the making of electrical connections to the lower end of the protective device **10** from an external electrical circuit or load as indicated by the external electrical conductor or cable **L2**, the lower terminal member **T2** is mounted or disposed adjacent to the lower end of the electrically insulating member **40** and projects axially from the lower end of the insulating member **40** as shown in the drawing. More specifically, the terminal member **T2** includes a threaded stud portion which projects axially downwardly, as viewed in the drawing, and on which a centering or spacer member **97**, which may be generally triangular or circular in cross section, may be assembled and retained on the threaded portion on the terminal member **T2** between a shoulder portion of the terminal member **T2** and a nut (not shown) which is assembled on the other side of the centering member **97**. In order to hermetically seal the lower end of the inner bore **42** of the insulating member **40** and to assist in retaining the terminal member **T2** in its properly assembled position, a suitable means such as thermosetting resin of the epoxy type, as indicated at **94**, may be disposed in the inner bore **42** of the insulating member **40** to surround or embed the lower terminal member **T2**.

In order to provide an electrically conducting path between the terminal members **T1** and **T2** and to protect an electrical circuit which is represented by either the electrical conductor **L1** or the electrical conductor **L2**, a fusible element or fuse link **60** is electrically connected between the terminal members **T1** and **T2**. The fusible element **60** may be of the flat strip or ribbon type and is preferably composed of silver. The fusible element **60** includes a plurality of axially spaced notches or restricted cross-sectional areas, as indicated at **61** in the drawing, which may be V-shaped in configuration to provide a series of arcs during the operation of the protective device **10** with the sum of the arc voltages providing a current limiting effect which is known in the fuse art. As illustrated, the fusible element **60** is helically wound on an associated electrically insulating support member **28** which extends axially between the terminals **T1** and **T2**. The opposite ends of the fusible element **60** may be electrically connected and secured to the associated terminal members **T1** and **T2** by suitable means, such as brazing. In order to aid in arc extinction during the operation of the protective device **10**, the insulating support member **28** may be molded or cast from a suitable electrically insulating material which also evolves gases during a circuit interrupting operation which assist in arc extinction, such as a glass-polyester material with a suitable filler, such as aluminum trihydrate, for antitracking characteristics. The insulating support member **28** may be substantially rectangular in cross section.

In order to additionally aid an arc extinction or interruption during the operation of the protective device **10** and to provide the current limiting action which is particularly desirable in protecting certain types of electrical apparatus or equipment, the space between the inner bore **42** of the insulating member **40** and the fusible member **60** or between the inner bore **42** and the combination which includes the fusible element **60** and the associated insulating support **28**, is substantially filled with a finely divided or pulverulent or granular arc quenching material **26**, such as silica sand or quartz. The presence of the arc quenching material or filler **26** as indicated in the drawing is also important in preventing the occurrence of corona due to the presence of voids or air pockets which may result when a conventional fuse having its own insulating housing is assembled inside a separate bushing as in certain known structures. It is also important to note that the electrically insulating member **40** in the construction of the protective device **10** as just described performs the function of an electrically insulating housing for the fusible element **60**, the insulating support member **28** where provided and the arc quenching material **26**, as well as providing the necessary electrical insulation between the upper terminal **T1** and the supporting bracket **92** and between the lower terminal **T2** and said supporting bracket. In other words, during the normal operation of the protective device **10**, both of the terminals **T1** and **T2** are maintained at a relatively high potential with respect to the supporting bracket **92** or with respect to ground potential. Portions of the insulating member **40** between the supporting bracket **92** and the respective terminal members **T1** and **T2** as indicated at **40C** and **40D**, respectively, are sufficient to withstand the potential applied between the respective terminals **T1** and **T2** and the supporting bracket **92**, which may be metallic and electrically connecting as previously mentioned. The construction of the protective device **10** therefore eliminates the need for a separate pair of support insulators which are normally disposed at the ends of a conventional high voltage power fuse of the type described.

In the operation of the protective device **10**, when the current flowing from a source of electrical power which may be either the circuit represented by the electrical conductor **L1** or the circuit represented by the electrical conductor **L2** to the load circuit represented by the other electrical conductor at the opposite end of the protective device **10** increases to an abnormal value the fusible element **60** will fuse or melt at one or more of the plurality of constricted portions **61** to result in a plurality of arc voltages which will effectively limit the current through the protective device **10** to a value which is referred to as "let-through current" and which is normally much less than the available fault or short circuit current which might otherwise result. The arc quenching material to the inner bore **42** of the insulating member **40** cooperates with the fusible element **60** during an interrupting operation to form a fulgurite as is well known in the fuse art. The thermal mass of the insulating member **40** is uniquely adapted to cooperate with the fusible element **60** and the arc quenching material **26** in dissipating heat during the normal operating condition of the protective device **10** to coordinate the thermal operating characteristics of the protective device **10** with the type of electrical equipment or circuit which is being protected by the protective device **10**. It is important to note that the outwardly projecting portions or petticoats **44** of the insulating member **40** function as heat radiating surfaces which assist in determining the time-current characteristics of the protective device **10** considered as a current limiting fuse structure. It is also to be noted that after the fusible element **60** melts or fuses and the abnormal or fault current is interrupted by the protective device **10**, the portion of the insulating member **40** between the terminal member which remains energized after the interrupting operation is sufficient to withstand the potential between the still energized terminal member **T1** or **T2** and the supporting bracket **92**. In addition, the insulating member **40** assists in providing the required electrical insulation between the terminals **T1** and **T2** after the fusible element **60** has melted or fused to interrupt the abnormal current during an interrupting operation of the protective device **10**.

In the assembly of the protective device **10**, the terminal members **T1** and **T2** are formed from a suitable electrically conducting material, such as copper, and may be molded into the opposite ends of the insulating support member **28** where

such a support member is provided. The fusible element **60** may then be assembled on the support member **28** by helically winding the fusible elements **60** on the support member **28** and then securing the upper and lower ends of the fusible element **60** to the associated terminal members T1 and T2 by suitable means, such as brazing. The cross pin **64** may then be assembled on the terminal member T1 and the centering member **97** as well as the associated nut may be assembled on the terminal member T2. A subassembly which includes the fusible element **60** and a support member **28** may be then assembled into the upper end of the insulating member **40**, as viewed in the drawing, with the cross pin **64** being positioned within the radial slot provided in the upper end of the insulating member **30** to prevent rotation of the subassembly after the protective device **10** is completely assembled. After the fusible element **60** and the support member **28** are assembled in the inner bore **42** of the insulating member **40**, the insulating member **40** may be sealed at the upper end by the assembly of the gasket member **62** and the connector **72** on the terminal member T1 to thereby prevent the entrance of moisture or other contaminating materials into the upper end of the inner bore **42** of the insulating member **40** during long periods of service particularly in outdoor applications. After the upper end of the insulating member **40** is sealed as just described, the insulating member **40** may be positioned with the opening of the inner bore **42** adjacent to the terminal member T2 substantially reversed from the position shown in the drawing with the opening around the terminal member T2 being then at the vertically upper end of insulating member **40** to permit the filling of the inner bore **42** of the insulating member **40** with the arc quenching material **26** which may then be compacted by any suitable means, such as vibration or other methods. After the arc quenching material **26** is in position inside the inner bore of the insulating member **40**, the thermosetting resin which forms the sealing member **94** and which includes any desired or suitable filler may be poured in the insulating member **40** around the terminal member T2 to cure or polymerize or place to thereby seal the lower end of the inner bore **42** of the insulating member **40** and to secure the terminal member T2 in the position shown in the drawing. The connector **74** may be then assembled on the terminal member T2 along with the gasket member **62** to complete the assembly of the protective device **10**.

The protective device embodying the teachings of this invention has several advantages. For example, since an elongated protective device as disclosed is adapted for mounting at only a single location along its length, the protective device eliminates the need for a pair of separate insulator supports which would normally be provided at the opposite ends of the protective device **10** and therefore permits a relatively more compact construction of the overall mounting arrangements. In addition, utilizing the inner bore of an electrically insulating member as disclosed results in a relatively stronger housing for the fuse parts which are disposed in the inner bore of the insulating member and increases the effective thermal mass which is available to determine the time-current characteristics of the protective device considered as a current limiting fuse. Due to the increased thermal mass provided by the insulating member **40**, the time-current characteristic of the protective device **10** has a more inverse characteristic than that of a conventional current limiting fuse to permit increased or greater short time overload performance of the electrical apparatus which is protected by the protective device **10**. The more inverse characteristic provided by the protective device **10** is desirable since all or most types of electrical apparatus have an inverse load-time capability and the protective device **10** allows greater utilization of this capability without sacrificing a margin of protection in the overall range of fault currents. A conventional current limiting fuse is deficient in this respect due to its time-current characteristic. Other types of fuses, such as expulsion fuses or fuses employed in fuse cutouts, which are not of the current limiting type have more inverse time current characteristics than those of conventional current limiting fuses but do not have comparable interrupting characteristics or capability. The protective device **10**, therefore, combines both the inverse time current characteristic which a conventional current limiting fuse does not provide and the greater interrupting capability of such a current limiting-type fuse.

As previously noted, the outwardly projecting portions or petticoats provided on the insulating member **40** serve to increase both of the electrical insulating creepage paths or distances along the outer periphery of the insulating member **40** between the supporting bracket **92** and each of the terminal members T1 and T2. The outwardly projecting portions or petticoats also function as heat radiating surfaces which increase the ability of the insulating member **40** to dissipate the heat which results during a normal operation of the protective device **10** and to permit the thermal coordination of the protective device with the equipment or circuits being protected. The larger heat radiating surface of the insulating member **40** due to the larger outer diameter of said member and the petticoats **44** provides more effective cooling than that in a conventional current limiting fuse. The applicant's construction results in a relatively higher continuous current rating for a given size or cross section of the fusible element **60** and a relatively lower "let-through" current than that of a conventional current limiting fuse having the same continuous current rating. In other words, the "let-through" current of a current limiting device of fuse varies directly with the cross-sectional area of the fusible element or elements. Since the protective device **10** permits a smaller cross-sectional area of the fusible element **60**, the "let-through" current is therefore smaller.

Another advantage of the disclosed construction of a protective device is that each portion of the insulating member **40** between the supporting bracket **92** and each of the terminal members T1 and T2 is sufficient to support the potential applied between both of said terminal members and the supporting bracket **92** and to support the potential between one of the terminal members T1 and T2 and the supporting bracket **92** after the protective device **10** has interrupted an abnormal or fault current. A further important advantage of the protective device disclosed is that the structural strength of the insulating member **40** uniquely lends itself to being supported at only a single location along its length.

Since numerous changes may be made in the above-described apparatus and different embodiments of the invention may be made without departing from the spirit and the scope thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. An elongated high voltage current limiting protective device comprising a hollow, generally cylindrical, electrically insulating member having an axially extending inner bore, first and second terminal members mounted on said insulating member at the opposite ends of insulating member and projecting axially from the ends of said insulating member, one or more fuse elements disposed in said inner bore and laterally spaced from the inner bore, each of said one or more fuse elements being electrically connected between said terminal members and including a plurality of axially spaced restricted cross-sectional areas, a pulverulent arc quenching material substantially filling the space between said one or more fuse elements and said inner bore and being in heat transferring relation with both said one or more fuse elements and the inner bore of said insulating member, means secured to each of said terminal members for connecting an electrical conductor to each of said terminal members, and only one metallic supporting bracket secured to said insulating member axially intermediate the ends of said insulating member, said insulating member including a plurality of axially spaced, outwardly projecting portions between said supporting bracket and each end of said insulating member, the thermal mass of said insulating member and said outwardly projecting portions thereof which function as heat radiating surfaces during the operation

of said current limiting device cooperating with said one or more fuse elements and said arc quenching material to permit a smaller cross-sectional area of each of said one or more fuse elements for a particular continuous current rating of said current limiting device.

2. The combination as claimed in claim 1 wherein said pulverulent arc quenching material comprises silica sand.

3. The combination as claimed in claim 2 wherein each of said one or more fuse elements is formed from silver.

4. The combination as claimed in claim 1 wherein said connecting means secured to each terminal member comprises a solderless-type terminal connector.

5. The combination as claimed in claim 1, wherein the outer surface of said insulating member between each end of said insulating member and said metallic supporting bracket is sufficient to withstand a predetermined potential normally applied between each of said terminal members and said supporting bracket.

6. The combination as claimed in claim 5 wherein said pulverulent arc quenching material comprises silica sand and said supporting member is disposed at approximately the middle portion of said insulating member.

7. The combination as claimed in claim 1, wherein an electrically insulating support is disposed in and spaced from the inner bore of said insulating member to extend axially between said terminal members, said one or more fuse elements being mounted on said insulating support.

8. The combination as claimed in claim 7, wherein said pulverulent arc quenching material comprises silica sand.

9. The combination as claimed in claim 7, wherein each of said one or more fuse elements is helically wound on said insulating support.

10. The combination as claimed in claim 7 wherein each of said one or more fuse elements is formed from silver.

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