United States Patent

Lockie et al.

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[45] **Aug. 22, 1972**

[54] **ELECTRICAL CONNECTOR**

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[73] Assignee: **Westinghouse Electric Corporation,** Pittsburgh, Pa.

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[52] **U.S. Cl.**.....**337/201,** 337/224

[51] **Int. Cl.**.....**H01h 85/02,** H01h 85/22, H01r 13/46

[58] **Field of Search** .....174/73; 337/191, 192, 193, 337/197, 201, 205, 224, 263; 389/45, 59, 60, 60 E, 61, 111, 143

[56] **References Cited**

UNITED STATES PATENTS

3,513,425	5/1970	Arndt	337/201
3,345,483	10/1967	Leonard et al.	337/205 X
3,307,137	2/1967	Tordoff et al.	174/73 X
3,116,386	12/1963	Sperzel	339/59 X
2,593,426	4/1952	Fahnoe	337/224

FOREIGN PATENTS OR APPLICATIONS

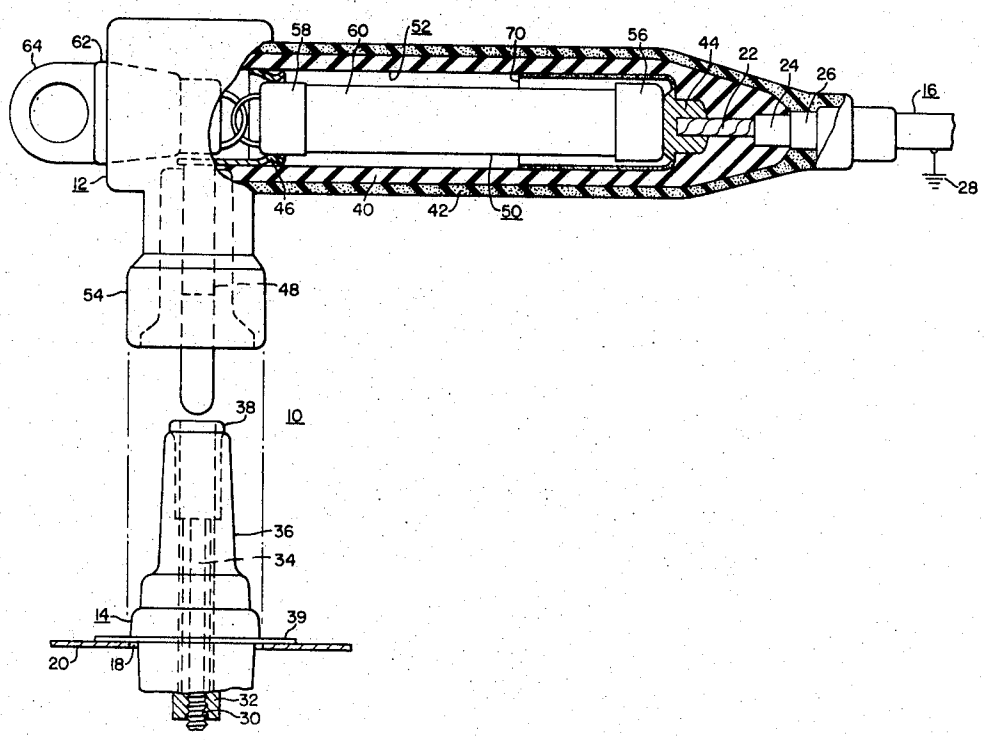
828,861	2/1960	Great Britain	337/224

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[57] **ABSTRACT**

A fusible plug-in type electrical connector for interconnecting a shielded electrical conductor with a load circuit. The removable plug-in portion of the connector includes means for reducing the electrical stress adjacent the electrodes of the fuse, one of which is still at line potential after the fuse has interrupted the circuit.

6 Claims, 3 Drawing Figures



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2 Sheets-Sheet 1

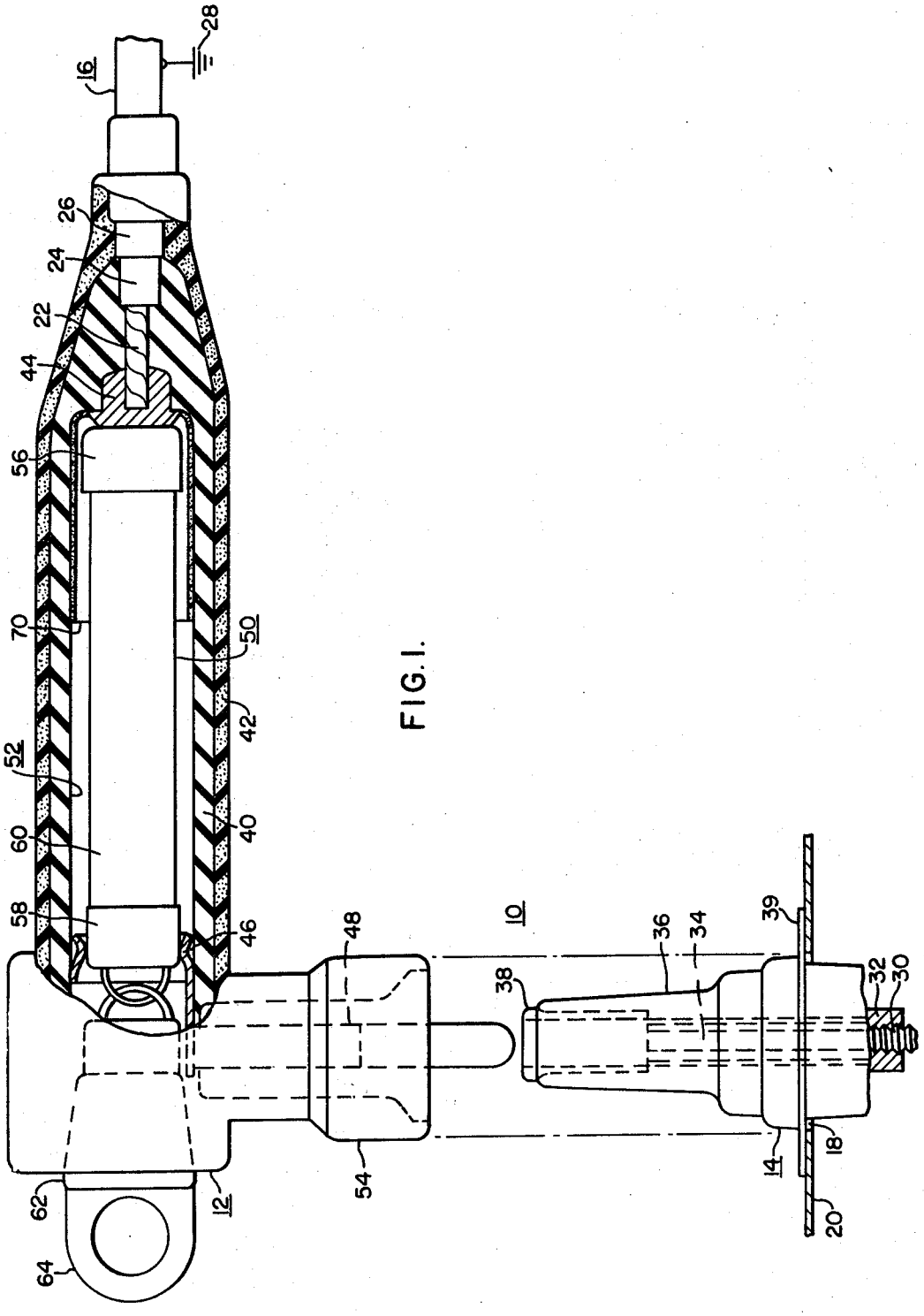


FIG. 1.

WITNESSES

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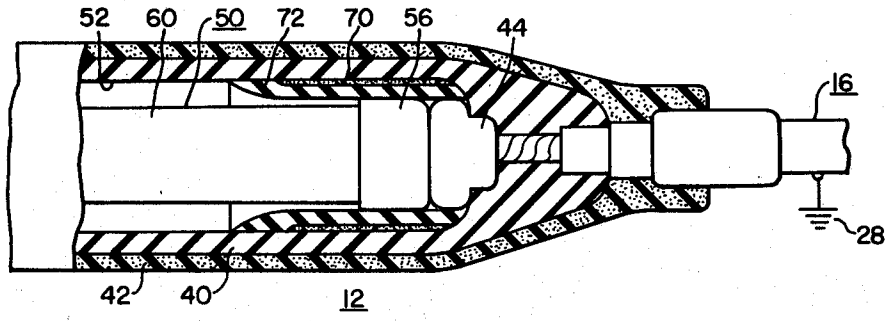

52
60
50
72
70
56
44
16
28
42
40
12

FIG.2.

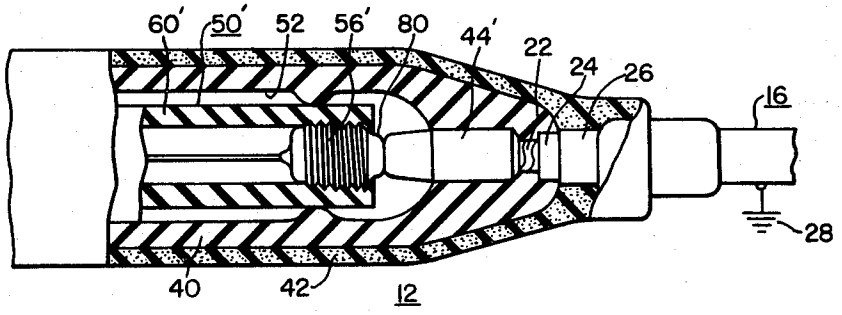

60'
50'
52
56'
80
44'
22
24
26
16
28
40
42
12

FIG.3.

ELECTRICAL CONNECTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The invention relates in general to high voltage connectors, and more specifically to electrical connectors of the fusible plug-in type.

2. Description of the Prior Art:

Copending application Ser. No. 702,630, filed Feb. 2, 1968, now U.S. Pat. No. 3,512,118, which is assigned to the same assignee as the present application, discloses a new and improved electrical connector which connects a shielded electrical cable to a load circuit via a current limiting fuse disposed in a load-break disconnect. The current limiting fuse limits the power dissipated at the separable contacts of the disconnect, in the event the disconnect is operated under fault conditions.

While the current limiting fuse accomplishes the desired function, corona, which may cause erosion, burning or tracking, has been observed on the inside surface of the fuse holder, after the fuse interrupts a fault.

SUMMARY OF THE INVENTION

Briefly, the present invention is a new and improved fusible plug-in type electrical connector or disconnect, which solves the problem of the prior art, wherein the inside surface of the fuse holding portion of the connector is attacked following a circuit interruption by the fuse.

In normal operation, with the fusible element of the fuse intact, all of the internal metallic parts of the fuse, fuse holder, and connector, are virtually at the same electrical potential, i.e., that of the central conductor of the cable to which the connector is attached. The conductive, or semiconductive outer surface of the connector, however, is connected to the grounded outer sheath of the cable. Thus, a high electrical stress exists between the internal metal parts and the outer surface of the connector. If this stress were to be applied to any air within the connector, it would produce corona which would damage the connector and/or produce radio interference.

A similar situation occurs in conventional plug-in connectors which do not contain fuses. In the non-fused connector, it is common practice to line the inner surface of the connector insulation with conductive material which is connected to the internal metal parts. This construction removes the electrical stress from the air inside the connector, and corona is minimized or eliminated.

This construction, however, cannot be applied to fusible connectors. When the fusible element of a fuse in a fusible connector melts, due to a fault in the load circuit, the internal metal parts at the load end of the fuse assume ground potential, while those at the opposite end remain at line potential. If conductive material was used to line the inner wall of the fuse chamber, it would bridge the fuse insulation, and the fuse could not perform its intended function of disconnecting a fault from the line. Providing a simple discontinuity in the conductive liner would not solve the problem, since line-to-ground potential would appear across the discontinuity when the fusible melts, metals causing corona in the adjacent air.

With this realization, a new and improved fusible electrical connector is provided which reduces the voltage gradient and the maximum stress adjacent one, or both, electrodes of the fuse, following a circuit interruption. In one embodiment of the invention, a material having a voltage dependent resistivity is disposed on the inner annular surface of the connector surrounding the electrode of the fuse which is still at line potential following the circuit interruption. This coating may be electrically connected to the live contact of the connector. A similar coating may be applied adjacent the other electrode of the fuse, if necessary.

In another embodiment, a resilient insulating liner is disposed between the live electrode of the fuse and the wall of the fuse chamber, to exclude air from this highly stressed area. This embodiment may be used in combination with a conductive, or semiconductive shield or coating disposed between the liner and the wall of the fuse chamber, with the shield being applied directly to the wall of the fuse holder, or being a part of the resilient member.

In still another embodiment, the fuse electrode which is still at line potential following a circuit interruption is constructed with a smaller outside diameter than the insulating body portion of the fuse, and the mating contact of the connector has substantially this same small diameter, to increase the clearance between the fuse electrode and the wall of the fuse chamber, as well as to dispose the insulating body portion of the fuse between the fuse electrode and the wall portion of the fuse chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages and uses of the invention will become more apparent when considered in view of the following detailed description and drawings, in which:

FIG. 1 is an elevational view, partially in section, of a new and improved fusible electrical connector of the plug-in type, constructed according to a first embodiment of the invention;

FIG. 2 is a fragmentary elevational view, partially in section, of the connector shown in FIG. 1, constructed according to another embodiment of the invention; and

FIG. 3 is a fragmentary elevational view, partially in section, of the connector shown in FIG. 1, constructed according to still another embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The recent emphasis on underground electrical distribution for residential users, has developed the need for moisture-proof connectors which may be quickly and safely operated to interconnect, or disconnect, a shielded cable and a load circuit. The hereinbefore mentioned copending application discloses such a connector or disconnect, with a current limiting fuse being used to limit the power dissipated at the contacts of the connector, in the event an attempt is made to connect the energized electrical cable to a load circuit having a fault thereon. While the current limiting fuse performs the function for which it was intended, it has been found that erosion or tracking occurs on the inner annular surface of the fuse chamber adjacent the electrode of the fuse which remains at line potential following a circuit interruption by the fuse.

Removing the grounded shield from the cable and fuse holder may solve this problem, as the electrostatic field would expand into a much larger area, reducing the stress around the live fuse electrode. Even here, however, if the distance between the electrode and inside wall of the fuse holder is small, excessive stress may still be created. If the shield is removed only from the connector, the shield on the cable is terminated in a stress cone, and a large clearance is provided between the electrode and the inside wall of the fuse holder, the damage to the fuse holder may be eliminated. However, both of these solutions are theoretical, and would not be tolerated in actual practice as a continuous shield extending over both the cable and fuse holder is preferred for safety reasons.

The present invention solves this problem of the prior art, while maintaining the grounded shield on the cable and the fuse holder. More specifically, FIG. **1** is an elevational view, partially in section, of a new and improved electrical connector **10** constructed according to the teachings of a first embodiment of the invention. Connector **10** includes a removable plug-in member **12**, and a stationary member **14**. The plug-in member **12** is electrically connected to a shielded electrical cable **16**, which in turn is connected to a source (not shown) of electrical potential. The stationary member **14** is electrically connected to a load circuit, such as a distribution transformer. Thus, stationary member **14** may perform the function of an insulating bushing, being mounted in sealed relation through an opening **18** in a casing or enclosure **20** of the electrical apparatus to be energized.

The electrical cable **16** includes a central or main conductor **22**, insulation **24** disposed about conductor **22**, and a conductive shield **26** disposed about insulation **24**, which is grounded as indicated at **28**.

The stationary portion of the connector **10** may be constructed in any suitable manner. For example, it may be constructed as described in the hereinbefore mentioned copending application. In general, stationary member **14** includes an axially disposed electrical conductor **30**, one end of which is adapted for connection to the encased electrical apparatus, and the other end of which is threadably engaged with a terminal or contact member **32**. Terminal **32** has a plurality of upwardly extending, circumferentially spaced spring finger members **34**, which are complementary to a terminal in the plug-in member **12**. An insulating body member **36** surrounds the electrical conductor **30** and terminal **32**, and a sleeve **38** of arc extinguishing material is disposed at the upper end of the fingers **34**, for extinguishing an arc generated when the plug-in member **12** is removed from its cooperative circuit closing arrangement with the stationary member **14**. A metallic flange member **39** may be embedded in the insulating body portion of the stationary member **14**, which may be welded, or otherwise fastened to the casing **20** of the electrical apparatus.

Plug-in member **12** includes an insulating body portion **40**, shielding means **42** surrounding the insulating body portion **40**, first and second electrical contacts **44** and **46**, respectively, a terminal member **48**, and a fuse **50**.

The insulating body portion **40**, which may be formed of any suitable insulating material, such as a molded rubber, defines a tubular chamber **52** for receiving the fuse **50**. The first and second electrical contacts **44** and **46** are disposed in spaced relation within chamber **52**, with the first contact **44** being disposed at one end of the chamber and electrically connected to the conductor **22** of the shielded cable **16**. The second electrical contact **46** is disposed near the other end of chamber **52**, and is connected to terminal **48**, which may be offset from the axis of the chamber **52** to provide an elbow type plug-in connector. Terminal **48** depends from one end of a tapered chamber, defined by a shroud **54** of insulating material, which is complementary to the portion of insulating body member **36** of stationary member **14** which extends upwardly from casing **20**. The lower end of terminal **48** has attached thereto a rod-like member formed of an arc extinguishing material, which, like sleeve **38**, aids in extinguishing an arc drawn when terminals **48** and **32** are disengaged.

Fuse **50**, which may be a current limiting fuse as disclosed in the hereinbefore mentioned copending application, has first and second electrodes or ferrules **56** and **58**, respectively, which are mounted on the ends of an insulating body member **60**, and which are electrically interconnected with a fusible element (not shown) which extends through an opening in the insulating body member **60**. The fuse **50** is held in a circuit closing arrangement between contacts **44** and **46** by the spring type fingers on contact **46**, and a suitable spring arrangement (not shown) which urges electrode **56** of fuse **50** against electrical contact **44**. Fuse **50**, as illustrated, is connected to a plug-like member **62**, which is mechanically linked with the fuse **50**, and which closes the other end of the fuse chamber **52**, when it is in assembled relation with the plug-in member **12**. The plug-like member **62** has a handle **64** attached thereto which may be engaged with a hook stick for withdrawing the plug-like member **62** and fuse **50** when it is desired to interrupt the circuit or replace the fuse. It will be noted that the second contact member **46** is constructed to allow the fuse **50** to be advanced therethrough, to enable it to assume the proper operating position when it is inserted into the fuse holder.

For purposes of operator safety, it is desirable to maintain a grounded shield between the energized conductive portion of connector **10** and operating personnel. Thus, the outer layer **42** of the plug-in connector is formed of a conductive or semiconductive material, such as rubber filled with particulated carbon, or particulated silicon carbide, and it contacts the grounded shield **26** of the electrical cable **16**, to continue the grounded shield of the cable about the connector.

When the fusible element of fuse **50** melts to interrupt the circuit due to a fault on the load side of fuse **50**, terminal **48**, contact **46**, and electrode **58** drop to zero potential, while conductor **22**, contact **44** and electrode **56** remain at line potential. This causes the electrostatic field to change, sharply increasing the maximum voltage stress adjacent electrode **56** and conductor **44**, which initiates corona discharges in the surrounding air. The corona attacks the inner annular wall of fuse chamber **52**, causing erosion, burning, carbonizing, and tracking across this surface. FIG. **1** illustrates a solution to this problem, which does not require any major modification to the connector, or a substantial

increase in its manufacturing cost. A coating **70** of stress grading material is applied uniformly about the inner annular surface of chamber **52**, starting at and preferably contacting the first electrical contact **44**, and extending towards contact **46** for a distance sufficient to surround electrode **56** and to reduce the stress at the terminus of the coating to a level which will not initiate partial discharges or corona. Coating **70** may be a semiconductive paint, i.e., a paint having a predetermined voltage dependent resistivity which conducts current in direct response to the magnitude of the electrostatic stress adjacent thereto. If desired, a coating similar to coating **70** may be disposed adjacent to and contacting the second contact member **46** further improving stress distribution between contacts **44** and **46**.

If coating **70** is semiconductive, it may contain particulated silicon carbide formulated to provide a resistivity range which is not so high that the coating acts like an insulator, which would render it ineffective, and which is not so low that in order to terminate the coating without corona it would have to be of an impractical length.

FIG. **2** is a fragmentary view of the plug-in portion **12** of connector **10** shown in FIG. **1**, constructed according to another embodiment of the invention, with like reference numerals indicating like components. In this embodiment, an annular resilient, insulating liner member **72** is disposed between the shield or coating **70** and the electrode **56** of the fuse **50**, with its axial opening being sized to snugly accept the electrode **56**, and its length sufficient to enclose the end of coating **70** which is remote from contact **44**. In this embodiment, the coating **70** may be a good electrical conductor, such as an aluminum coating, it may be partially conductive, such as a coating containing particulated carbon, or it may be semiconductive, i.e., having a predetermined voltage dependent characteristic, such as provided by silicon carbide coating formulations. In any event, enclosure of the edge of coating **70** substantially reduces the length of coating which is required. Also, instead of applying the coating **70** to the inside wall portion of chamber **52**, as illustrated in the embodiment of FIG. **1**, it would also be practical to make the coating or shield an integral part of the resilient liner **72**.

FIG. **3** is a fragmentary view of the plug-in portion **12** of connector **10** shown in FIG. **1**, constructed according to still another embodiment of the invention. Like reference numerals in FIGS. **3** and **1** indicate like components. In this embodiment of the invention, the construction of the fuse **50** is changed, as illustrated by fuse **50'** in FIG. **3**, whereby the fuse has an internal or recessed electrode **56'** disposed on at least the end which makes electrical contact with the electrical contact **44** and the electrical contact **44** is also modified, as illustrated at **44'** in FIG. **3**.

More specifically, the insulating body portion **60'** of fuse **50'** has its internal diameter threaded at at least one of its ends, for receiving and threadably engaging electrode **56'**, which has a threaded outside diameter, and a contact portion **80** which extends outwardly from the end of the fuse body for a short predetermined distance. The contact portion is much smaller in diameter than the insulating body portion **60'** of the fuse **50'**, and is similar to a button type contact or pencil electrode.

The first electrical contact **44'** is also a pencil-like contact, with the portion which makes electrical contact with portion **80** of electrode **56'** being of substantially the same outside diameter as portion **80**. This construction places the insulating body portion **60'** of the fuse **50'** between the major portion of electrode **56'** and the inside wall of chamber **52**, and also substantially increases the distance through the air between the electrode **56'** and contact **44**, and the wall of chamber **52**, with both factors contributing to a lowering of the electrical stress at the wall of chamber **52**. This embodiment may also be used in cooperation with the other embodiments disclosed herein. For example, a resilient liner may be disposed between the fuse body **60'** and the wall of chamber **52**, a conductive or semiconductive coating or shield may be disposed on the inner wall as illustrated in FIG. **1**, or between a resilient liner and the wall, as shown in FIG. **2**, with the shield or coating being connected to contact **44'**, if desired.

In summary, there has been disclosed a new and improved fusible electrical connector for connecting a shielded electrical cable to a load circuit, with the connector having load-make and load-break capabilities, and with the fuse limiting the power dissipated at the contacts of the connector, in the event of a fault occurring in the load circuit. Further, when the fuse clears the circuit after a fault, the connector is protected from corona damage which occurs in prior art devices due to a change in the electrostatic field following a blowing of the fuse. This is accomplished by reducing the maximum electrical stress about the fuse electrode which is still at line potential, or about both fuse electrodes, by grading the stress, by excluding air from the highly stressed area, by enlarging the clearances between the electrode and wall of the fuse chamber, or by a combination of these constructions.

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 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.

We claim as our invention:

1. An electrical connector comprising:

a plug-in member adapted for connection to a shielded electrical conductor, said plug-in member including an insulating body portion, first electrical shielding means surrounding said insulating body portion adapted to contact the shield of the shielded electrical conductor, first and second electrical contacts and a terminal,

said insulating body portion defining a tubular chamber, with said first and second electrical contacts being disposed in spaced relation therein,

said first electrical contact being adapted for connection to the shielded electrical conductor,

said terminal being connected to said second electrical contact, and adapted to releasably engage a complementary terminal,

a fuse having an insulating body member, first and second electrodes, and a fusible element connected between its first and second electrodes, said fuse being removably disposed within the chamber of said insulating body portion with its

first and second electrodes in contact with said first and second electrical contacts respectively, and with its first and second electrodes spaced from the wall of the tubular chamber of said insulating body portion,

second electrical shielding means disposed within the chamber of said plug-in member, in contact with the annular inner surface thereof, starting adjacent to said first electrical contact and extending toward said second electrical contact for a predetermined distance, to surround and shield the first electrode of said fuse, said second electrical shielding means having a voltage dependent resistivity selected to prevent corona discharges from occurring between the first and second electrodes of said fuse when the fusible element melts and interrupts the circuit between the first and second electrodes, and a resilient liner member disposed within the chamber of the plug-in member, having an aperture sized to snugly but removably receive the fuse, and disposed adjacent to the first electrical contact, between the second shielding means and the fuse.

2. An electrical connector comprising:

a plug-in member adapted for connection to a shielded electrical conductor, said plug-in member including an insulating body portion, first electrical shielding means surrounding said insulating body portion adapted to contact the shield of the shielded electrical conductor, first and second electrical contacts, and a terminal,

said insulating body portion defining a tubular chamber, with said first and second electrical contacts being disposed in spaced relation therein,

said first electrical contact being adapted for connection to the shielded electrical conductor,

said terminal being connected to said second electrical contact and adapted to to releasably engage a complementary terminal,

and a fuse having an insulating body member and first and second electrodes, said fuse being disposed within the chamber of said plug-in member, with its first and second electrodes in contact with the first and second electrical contacts, respectively,

the first electrical contact of said fuse having a diameter smaller than the outside diameter of its insulating body member, with said first electrical contact having a diameter which is substantially the same as that of the first electrode, to provide a substantial clearance between the first electrode and first electrical contact, and the surrounding chamber defined by the insulating body portion of said plug-in member.

3. The electrical connector of claim 2 including second electrical shielding means disposed within the chamber of said plug-in member, in contact with the inner annular surface thereof, starting adjacent the first electrical contact and extending towards the second electrical contact for a predetermined dimension, to surround and shield the first electrode of the fuse.

4. The electrical connector of claim 2 wherein the second electrical shielding means has a predetermined voltage dependent resistivity.

5. The electrical connector of claim 2 wherein the second electrical shielding means is electrically connected to the first electrical contact.

6. The electrical connector of claim 2 including a resilient liner member disposed within the chamber of the plug-in member, adjacent the first electrical contact, between the insulating body member of the fuse and the second shielding means.

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