

[54] **CURRENT LIMITER SYSTEM**

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[58] Field of Search. **337/158, 159, 191, 337/192, 193; 174/90, 71 R, 84 R**

[56] **References Cited**

UNITED STATES PATENTS

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[57]

ABSTRACT

The improved current limiter system includes aluminum terminal connectors at each end, the one end capable of connection to conducting elements such as an aluminum bus connector and at the other end the limiter may be connected to an aluminum conductor such as an insulated cable. The number of electrical contact points between the limiter and its connections is reduced in number but not in available contact area, thereby to produce a maximum of heat transfer. The heat transfer characteristics of the limiter are further enhanced in that air pockets or voids within the enclosed connection are reduced and contact area is large. The limiter is capable of being sheathed in a suitable insulating jacket without the necessity of taping its connection to the cable or to the bus bar.

10 Claims, 2 Drawing Figures

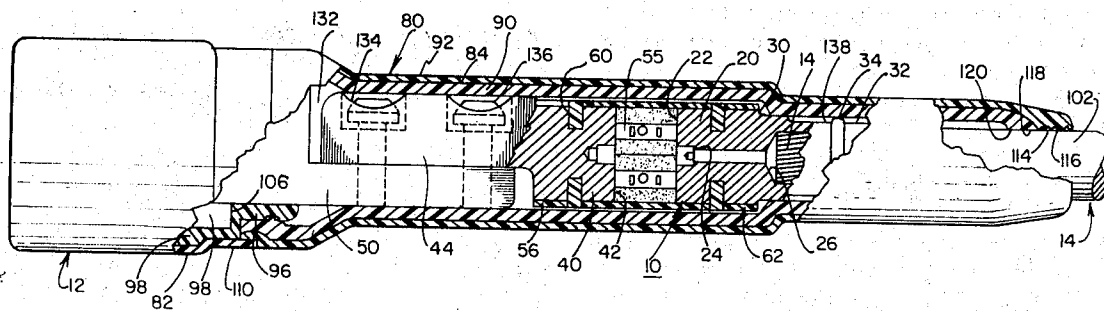


FIG 1

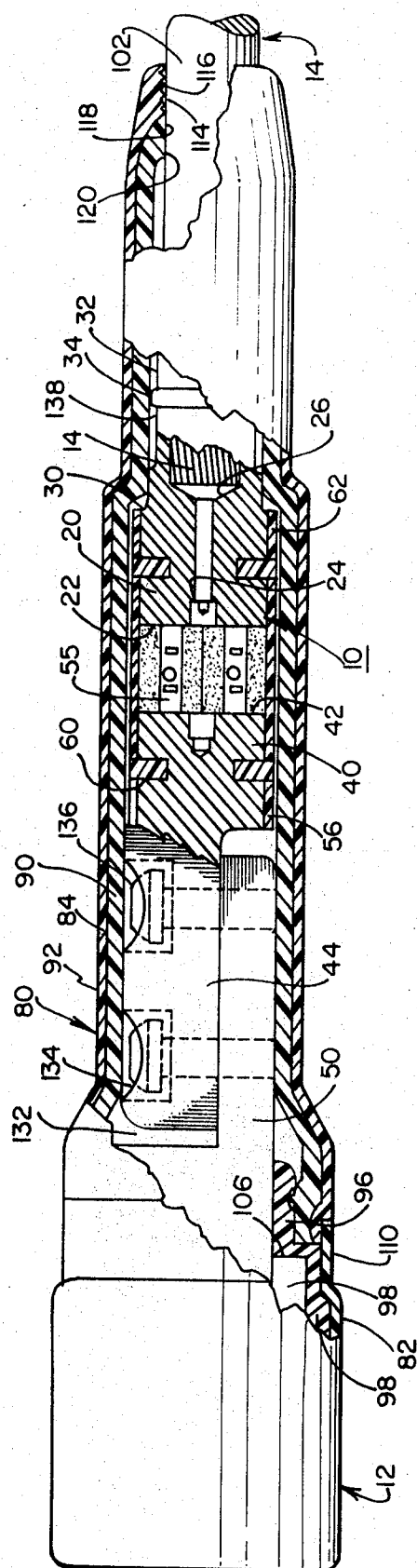
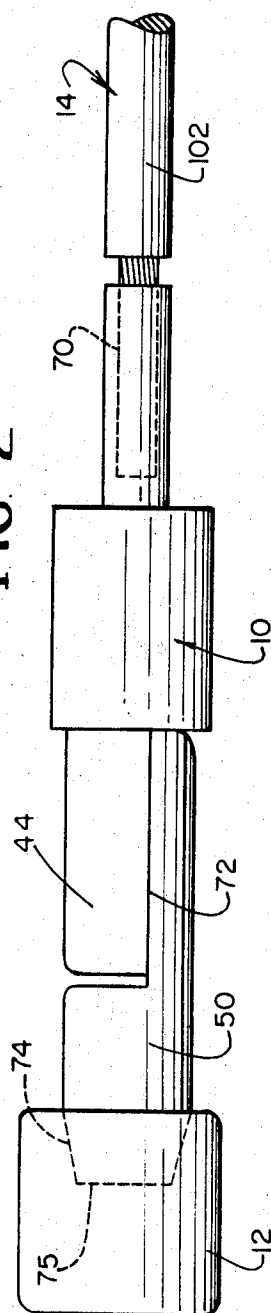


FIG. 2



CURRENT LIMITER SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

Current limiters or current limiting fuses are well-known in the art. Such fuses comprise a plurality of fusible elements connected between end members and aligned in a closing housing. The housing may, in some instances, contain a quartz sand matrix or may be a gas-filled housing. The limiter is placed in series in the line such that when line current exceeds a maximum value, the elements melt to open the circuit. In the type in which sand is used, the sand tends to quench the arc ensuring from the break of the heavy current path and thereby prevent a surge of current through the limiter. The sand may be melted by the heat of the arc into glass nodules. This approach is used where heavy currents are broken so that no arc, flame or gas is emitted from the limiter matrix, and the circuit is broken cleanly.

The fusible elements or links are generally made of silver with the end members made of copper for connection to copper cable and/or copper terminals.

2. DESCRIPTION OF THE PRIOR ART

Self-contained and self-protecting cable limiters provide the protection required for network distribution systems, and sand-filled limiters have become increasingly necessary for voltages as low as 120/240 and 120/208 volt systems as loads increase. Rated 600 volts or less, they may be used to interrupt circuits having maximum fault levels of 200,000 amps RMS symmetrical with a high degree of current limitation. Such limiters allow each individual copper conductor to operate safely at close to its safe loading capabilities. Under fault conditions, the limiter will quickly interrupt the current and isolate the affected circuit to prevent further damage. The limiter will clear a fault without any visible external indication, and a sand-filled limiter does not of itself become a hazard as would a limiter that may emit uncontrolled ionized gases or volatilized metals.

The present design of cable limiters available to the utility companies for power usage are designed to function in a completely "copper" system. The connector or bus bar is copper, the limiter terminals are copper and the cable is copper. Should the utility desire to use aluminum cable, it becomes a very difficult task to make a satisfactory electrical connection because the most common limiter design provides a flat copper tang or terminal on one end to attach to the connector or bus bar and a tubular shaped copper crimp type terminal at the other end to permit the attaching of the cable.

Crimping aluminum cable in a copper terminal is not considered good practice by utilities. It is not recommended by connector manufacturers nor by cable manufacturers. It is, therefore, necessary for the utility to buy or make special additional adapters in order to make a "good" electrical connection. These special adapters add considerable cost due to the additional parts required, add measurably to the length of the connection, and result in a more difficult and time consuming job of assembling the system and thereafter sealing the connection and, last but not least, these adapters introduce additional current transfer junctions into the connection.

SUMMARY OF THE INVENTION

The present invention comprises a low cost current limiter providing a degree of protection, comparable to that of the prior art approaches within a system designed for use with aluminum cable. The system is capable of being insulated with slip-on sleeve insulating members to allow the system to be used safely for power distribution purposes indoors, outdoors or underground.

The limiter itself should have one end cap of aluminum, the end cap being integrally connected to a crimp connector for connection to the aluminum conductor which usually is an insulated cable but which could be a bus bar or the like. The opposite end cap preferably may also be fabricated of aluminum. The opposite end cap has connected thereto, preferably integral therewith, a flat aluminum terminal, the terminal being connected in turn to a bus connector or the like. Where the limiter is to be exposed to weather conditions or placed underground, an inner jacket or sleeve of suitable insulating material such as that known under the trade mark Nordel, surrounds the limiter and its connections, the jacket mating with a suitable jacket or sleeve on the bus and with the cable or its insulation. An outer sleeve of Neoprene rubber covers the connection mating with the bus jacket and at the other end with the sheath on the aluminum cable.

The inner faces of the limiter caps may be plated or otherwise surfaced with suitable metal capable of being soldered, such as copper or nickel to aid the soldering of the silver links to the end caps. A suitable tubular insulating housing may be used to enclose the limiter and maintain its elements firmly in place. It is therefore an object of the invention to provide a new and improved current limiter adapted for use with aluminum conductors such as cables, be used to enclose the limiter.

It is a further object of the invention to provide a novel current limiter whose construction minimizes the number of contact junctions between conductive members in the limiter connection and which minimizes the void spaces within a totally enclosed, insulated system.

It is a further object of the invention to provide a new and improved current limiter adapted to be fitted between a multi-terminal network bus connector and a cable conductor where both the connector and the conductor are made of aluminum.

Other objects, features and advantages of the invention will become apparent from the following detailed description viewed in conjunction with the drawings as now described briefly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional view through a generally cylindrical limiter system using my invention and housed in an insulating jacket; and

FIG. 2 is a schematic side view of a limiter employing my invention.

DETAILED DESCRIPTION

In FIG. 1, I show a current limiter 10 of the sand-filled type employing my invention. Limiter 10 is connected at the left end, as viewed in FIG. 1 to the terminal connector of a bus bar of the type shown in copending U.S. application, Ser. No. 80,399 filed Oct. 13, 1970, of which I am co-inventor and which is assigned to the Assignee herein. At its other end, the limiter is

connected to cable 14, all three of these component elements being fabricated of aluminum.

The limiter is generally cylindrical and includes an end cap 20 having a flat circular face 22. Face 22 may have a center opening 24 co-axial with and resulting from the axial cable opening 26 extending through the end cap 20. The end cap has a generally cylindrical body along the height of which there is an inwardly directed cylindrical shoulder 30 which leads to the integral tubular crimp portion 32. The crimp portion is conventionally adapted to receive therein a multiple strand cable 14, the cable insulation (not shown) having been stripped from the end in known fashion. The crimp terminal portion 32, as is known, may have reinforcing ribs 34 on its outer surface in any desired pattern.

Spaced from end cap 20 is the opposed end cap 40 which is cylindrical in configuration with a circular face 42 parallel to the face 22 of opposed cap 20. Face 42 may have a small diameter bore extending partially through the end cap. The end cap 40 also has a generally cylindrical body which terminates at its outer end in flat terminal section 44 designed for the bolt connection to the flat terminal 50 of the bus bar 12.

Extending between the faces of the opposed end caps are the fuse links 55 which may be any known design and as shown comprise ribbon-type links preferably of silver. The number of links and their geometry depend on the required current carrying capacity of the limiter.

The links 55 may be affixed to the end caps 20 and 40 in any suitable fashion such as compression fit within grooves or soldered to the end caps. I have found that by suitably covering the faces 22 and 42 with metal capable of being readily soldered, I get a superior bonding effect in the soldering operation. I have found that by either plating with tin or copper alloy or by adhering a disc or the like to the face, I achieve a surface to which the links can readily be soldered and which provides a superior path of continuous electrical conductivity.

The end caps 20 and 40 are held in spaced apart, co-axial relationship by the outer casing or housing 56 of the limiter. The outer casing is an imperforate tubular member of heat shock resistant material and may be mounted on the end caps under axial compressive force and pinned or otherwise held by inwardly directed tabs or pins 60 projecting into suitable recesses in the peripheral walls 62 of the end caps. The space within the casing 52 and between the end caps in the embodiment shown is filled with a suitable arc quenching pure quartz sand.

Within the system in FIG. 2, we show one major feature of our invention, that feature being a system which provides only three junctions for current transfer outside of the limiter itself. These transfer junctions are noted as 70, 72 and 74. The first of the junctions, 70, is in the crimp connection of terminal 32 to the cable 14. The second transfer junction, 72, is the bolted connection of limiter terminal 44 and bus terminal 50. The last of the transfer junctions, 74, is within the press fit of the cylindrical of frusto-conic end 75, terminal bus 50 within bus bar 12. This press fit may be of the type shown in the co-pending application previously referred to.

This minimum number of serial current transfer junctions produces a number of advantages. A major one of these is it is almost axiomatic that the number of field

problems is directly related to the number of serial contact junctions, thus by reducing the number of serial contact junctions the problems arising in the field should be sharply reduced. The problems produced by contact junctions generally fall into two categories (1) high resistance across the contact junctions and (2) heat transfer and heat dissipation across the junctions.

By reducing the number of serial contact junctions, the number of resistive junctions is reduced and the resistance losses lessened. Second, the breaks in the conductive heat transfer path are lessened leading to a more uniform and improved heat transfer through the system.

Further, of course, the lower the number of components the less assembly steps required in assembly, thereby lessening the chances of human errors in assembly and lessening the assembly costs.

A limiter, of course, has the tendency to heat especially during high current carrying periods, hence the need for improving the heat transfer characteristics is duly important in limiter protected connections.

The system as shown may be aluminum from the bus bar 12, its terminal 50, the integral limiter terminal and end cap 40, the integral end cap and crimp terminal 40 and cable 14. By eliminating dissimilar metals in this system, the heat transfer characteristics are even further enhanced. The problem of heat generation across boundaries of dissimilar metals is minimized, the latter being an important factor in systems designed for normal high current carrying capacity.

By using all aluminum components, the cost of the system is also appreciably reduced.

A double thickness jacketing arrangement similar to that shown in the co-pending application previously referred to, is shown in FIG. 1. Such an arrangement would be used where the limiter is to be exposed to the elements or buried.

The assembly or limiter system is insulated and sealed with a dual layer composite molded insulating jacket 80 which includes composite molded end cover 82 for encasing the bus bar and a composite, molded, slip-over self sealing insulating sleeves 84 for the cable limiter and cable connection. All insulating components of this system include a molded inner liner 90 of double thickness fabricated of an elastomeric material having high electric strength and good physical properties such as elasticity and resiliency, especially concerning permanent set characteristics in conjunction with heat aging. The outer layer 92 of all the components is also an elastomeric material, this material having high resistance to degradation by oils and excellent resistance to abrasion.

The single inner liner 90 of sleeve 84 sealingly mates with the cylindrical extension 96 of the inner insulating jacket 98 of the bus bar cover 82. The sleeve 84 covers the transfer junction 72, the limiter 10, the transfer junction 70 and at its outer end sleeve 84 sealingly mates with the insulation 102 on cable 14. The outer layer 92 of sleeve 84 terminates at the bus bar end and overlies the inner sleeve 48 of the bus bar in edge contact with an off-set wall 106 of the bus bar and within the end flap 110 of the outer bus bar jacket 112. The outer sleeve layer 92 overlies and covers the entire area of the inner sleeve liner 90 and terminates outwardly of the inner sleeve at one end in a sealing ring arrangement 114 against the cable insulation 102. Suitable annular ribs 116 on the inner wall of the ring 114 grasp

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and seal against the cable insulation, as do similarly configured ribs 118 on outer edge surface 120 of the inner sleeve liner 90.

The sheath is configured to fit comparatively tightly over the limiter and the connecting terminals to combinedly produce a minimum of air spaces or voids within the jacketed space. The remaining voids would be present (1) within the inclination 132 of the inner jacket as it approaches the bus jacket 82, (2) in the space 134 about the terminal bolts 136 and between the bolt terminal and the limiter, and (3) within the space 138 be radially outwardly of the ribs 34 on the crimped terminal 32. By reducing the voids or air pockets to a minimum, the heat transfer characteristics of the limiter are further enhanced and effected in an inexpensive manner.

While there has been shown what is at present thought to be the preferred embodiment of the invention, it is understood that changes may be made therein and it is intended to cover in the appended claims all such modifications which fall within the true spirit and scope of the invention.

I claim:

1. A current limiting apparatus for connecting an insulated cable having aluminum conductors to an aluminum bus bar, comprising: a one-piece, aluminum combined terminal and end cap member, said end cap member directly joined to the aluminum conductors of said cable, fuse links affixed to said cap member and extending within a sand matrix, a further end cap member of said limiting apparatus engaging the extending ends of said fuse links to complete a conductive path from said links, a terminal integrally connected to said further end cap member, a terminal connected to said bus bar and joined to said further end cap member terminal to complete a serial path from said cable conductors through said aluminum end cap member, said fuse links, said further end cap member and said bus bar terminal to said bus bar.

2. An apparatus as claimed in claim 1, wherein said aluminum end cap member comprises a generally circular face, said face being plated with a coating of copper for engagement with the fuse link ends.

3. An apparatus as claimed in claim 1, wherein said aluminum end cap member comprises a generally circular face, said face being plated with a coating of nickel for engagement with the fuse link ends.

4. An apparatus as claimed in claim 1, wherein said further end cap member is fabricated of aluminum.

5. A waterproof current limiting apparatus for connecting insulated cable having aluminum conductors to an aluminum bus bar, wherein said limiting apparatus is generally cylindrical in shape and includes terminals adjacent the axial ends thereof within the extension of the cylindrical shape of said apparatus, and comprising aluminum end cap members of said limiting apparatus engaging extending ends of a plurality of fuse links to complete a conductive path from said links, each of said terminals integrally connected to one of said cap members, a terminal connected to said bus bar and joined to one of said terminals to complete a serial path from said cable conductors through one aluminum end

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cap member, said fuse links, said other end cap member and said bus bar terminal to said bus bar; a dual layer, water-impervious insulating sleeve enclosing said apparatus and said terminals, a dual layer jacket covering said bus bar with the ends of the layers of said jacket interleaved with layers of one end of said sleeve, and the layers at the other end of said sleeve both engaging the insulation on said cable.

6. A current limiting apparatus for connecting an aluminum conductor to an aluminum bus bar, comprising a one-piece combined end cap and terminal member with one end comprising an end cap for the limiter and the other end joined directly to the aluminum conductors of said cable, fuse links affixed to said cap and extending within an enclosing housing, a further end cap of said limiting apparatus engaging the extending ends of said fuse links to complete a conductive path from said links, a terminal integrally connected to said further end cap and a terminal connected to said bus bar and joined to said further end cap terminal to complete a serial path from said conductor through said aluminum end cap through said fuse links, said further end cap and said bus bar terminal to said bus bar.

7. An apparatus as claimed in claim 6, wherein said further end cap comprises a combined end cap and terminal member fabricated of aluminum wherein said end cap comprises a generally circular face, a surface covering said face, said surface comprising an alloy of readily solderable metal, and said surface is positioned for engagement with the fuse link ends.

8. An apparatus as claimed in claim 7, wherein said aluminum end cap comprises a generally circular face, said face being covered by a coating of nickel alloy for engagement with the fuse link ends.

9. An apparatus as claimed in claim 7, wherein said aluminum end cap has an end covering thereover of copper alloy, and said end covering is positioned to engage one end of said first links.

10. A connection structure for connecting an insulated cable having aluminum conductors therein and an aluminum bus bar in a manner adapted for power distribution usage, said connection structure including a cylindrical current limiter, said limiter including a first end cap and second end cap, fusible links interposed between and spacing said end caps, a sand matrix disposed in the spacing between said caps and an outer insulating tubular casing surrounding said sand matrix and the end caps, said end caps being fabricated of aluminum and each including an end face in electrical contact with fusible links of said limiter, each of said end caps including a terminal end, the terminal end of said first end cap engaging a terminal extending from said bus bar to comprise a connection of substantially the circumference of said cylindrical limiter, and the terminal end of said second cap comprising a crimp terminal of approximately the circumference of said limiter, and an insulating sleeve member sealed to said cable and bus bar and, closely disposed about said limiter and to minimize air pockets within said connection structure.

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