AN ENCLOSED, NON-VENTED EXPULSION FUSE

Inventor: Gary Lee Schurter, Kirkwood, Mo.
Assignee: International Telephone and Telegraph Corporation, New York, N.Y.

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ABSTRACT
An enclosed, non-vented expulsion fuse structure includes a generally tubular fuse holder for receiving a universal fuse link. The fuse holder includes an inner tube lining of organic material of the type which decomposes in the presence of an arc which results when the fusible element of the fuse link melts or blows. The decomposition of the organic material evolves a turbulent, high-pressure, high-temperature permanent gas which acts to extinguish the arc. The fuse holder is enclosed except at one end thereof wherein the gas is discharged from the fuse holder through an opening at said end. The opening is closed into an enclosed chamber which receives the gas discharged from the fuse holder. The enclosed chamber has a thermal-quenching medium disposed therein.

8 Claims, 3 Drawing Figures
FIG. 1
PRIOR-ART

FIG. 2

TOTAL CLEARING TIME
FUSE A (EXPULSION FUSE)
TOTAL CLEARING TIME
FUSE B (CURRENT LIMITING FUSE)

TYPICAL TIME-CURRENT
CHARACTERISTICS

TIME
FUSE A CONTINUOUS RATING
FUSE B CONTINUOUS RATING

CURRENT
Ic

A
B
FIG. 3
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ENCLOSED, NON-VENTED EXPULSION FUSE

BACKGROUND OF THE INVENTION

This invention relates to an expulsion fuse structure, and more particularly, to an enclosed, non-vented expulsion fuse structure.

In the electrical power distribution art, expulsion fuses are well-known as exemplified in "The Expulsion Fuse," J. Slepian and C. L. Denault, A.I.E.E., Transactions, Volume 51, page 157, 1932. Expulsion fuses have been used extensively in overhead distribution systems in the form of overhead fuse cutouts. In its simplest form, the overhead fuse cutout can be considered as a meltable weak-link fuse installed in a relatively long tube lined with an organic material such as horn fiber. Upon sensing an abnormal condition in current, such as an overload or high-current fault, the link melts or blows, and an arc forms in the resulting gap. The normal energy loss from the arc is sufficient to decompose a portion of the organic liner into a high-pressure, highly turbulent gas which acts on the core of the arc to sufficiently cool and de-ionize the arc gap and thusly effect circuit interruption at a current zero. The resulting high-energy, high-pressure gas is expelled into the atmosphere in a loud, explosive and luminous cloud.

The violent operating characteristics of expulsion-type distribution fuses and cutouts are not only objectionable for many overhead applications due to, for example, environmental considerations, but also effectively preclude the use of an expulsion type fuse in underground distribution systems. That is, for underground distribution applications, the fuse must generally be insulated during operation for safety reasons as well as hermetically sealed to protect it from its environment. Consequently, the present practice in the art of underground distribution systems is to provide periodic above-ground overhead cutout fuses at those locations where a fuse is otherwise required. The installation usually necessitates the use of a pole of sufficient height to safely accommodate the overhead expulsion-type cutout fuse. This practice obviously does not provide a completely underground distribution system.

However, over the past several decades, the expulsion fuse cutout has evolved into a reliable circuit interruption device. Included in this evolution was the development of multitudes of different fuse links, most with widely varying time-current characteristics. In response to the need for order, an industry task group undertook the job of fuse link standardization out of which came the EEl-NEMA "K" and "T" fuse link time-current characteristics. The designation of these characteristics recognizes the full spectrum of coordination problems on both sides of the fuse cutout as well as the coordination among the different fuse sizes. These specifications are presently published by the American National Standards Institute, Inc. as ANSI C37.43-1969.

The "K" and "T" links became known as universal links in that fuse links made by the various manufacturers were electrically and mechanically interchangeable. Today, the "K" and "T" links account for a clear majority of all the fusible elements being utilized in power distribution systems. Thus, in order to accommodate the huge existing inventory of fusible elements and to perpetuate the standardization accomplished by the above-mentioned industry task force, any underground distribution system fuse must duplicate or closely correspond to the time-current characteristics of the ubiquitous, universal "K" and "T" fuse links.

One prior art form of a quiet, non-violent-operating distribution fuse is the current-limiting fuse, as exemplified in U.S. Pat. No. 3,766,509. These current-limiting fuses have the advantage in that they provide non-expulsion interruption even of very high currents; and that they can be readily installed for underground installations. However, these current limiting fuses have the disadvantage that they are difficult to coordinate with existing distribution protective devices as their time-current characteristics are not only different but are also sensitive to ambient temperature changes. Further, partial operation or a decrease in current-rating can result from sizable current surges in the distribution system and their BIL (Basic Impulse Level) and AC withstand characteristics may be erratic after a low-current interruption. Further, a high transient voltage can be generated by the interruption operation of the fuse itself; and, the replacement cost of the current limiting fuse is also relatively high.

Another known form of distribution fuse suitable for use in some underground distribution systems is the oil expulsion fuse. These fuses have the disadvantages of low current interrupt levels and the hazard of using oil as an interrupt medium. Further, as in the case of the current-limiting fuse, the associated fuse element (link) is not mechanically and electrically interchangeable with the above-described "K" and "T" fuse links.

A third prior art fuse type which avoids the characteristic violent operation of an overhead expulsion fuse is the boric acid fuse. The boric acid fuse is exemplified in: "The Expulsion Fuse," supra, and a "A Noiseless and Flameless High-Voltage Fuse," The Electrical Journal, July, 1932. These fuses utilize a specifically designed fuse element (link) which is disposed in a boric acid fuse liner. When the fuse element of the boric acid fuse melts, an arc develops across the resulting gap, and the gas given off by the boric acid is water vapor which is easily condensable to a liquid. However, these fuses have the disadvantages of high initial cost, high fuse-link replacement cost and that the time-current characteristics of the fuse elements are not the same as the above-mentioned NEMA "K" and "T" characteristics.

The above-mentioned publications teach the art that the principal gases arising from the decomposition of fiber are permanent and condense to a liquid only under very high pressure and at very low temperature; whereas, however, the gas given off by boric acid is water vapor which is easily condensable to a liquid. Hence, as taught therein, if means are included within the boric acid lined tube for condensing the water vapor generated, it is possible to close up completely the boric acid lined tube without the development of excessively high pressures.

These early teachings have survived the passage of time and, moreover, present-day enclosed, non-vented expulsion fuses are consistently constructed only with a boric acid liner and a specially designed fuse element. However, these expulsion fuses nevertheless exhibit the above-mentioned attendant disadvantages.

The present invention overcomes the problems and disadvantages of prior art fuses by providing an enclosed, non-vented expulsion fuse for use with universal fuse links having standard NEMA "K" and "T" time-current characteristics. Accordingly, the expulsion fuse is suitable for use in underground distribution systems,
submersed applications and those applications where a non-violent operating fuse having standardized time-current characteristics is required.

SUMMARY OF THE INVENTION

Briefly, an enclosed, non-vented expulsion fuse structure for use with universal fuse links is provided. The fuse link is of the type having a meltable link surrounded by a tubular member of a material which decomposes in the presence of an arc, and wherein an arc is drawn in the tubular member when the meltable link melts or blows. The fuse structure comprises in combination a fuse holder for receiving the fuse link, and the fuse holder includes a liner of a material of the type wherein energy loss from the arc decomposes a portion of the liner into a turbulent, high-pressure, hightemperature gas. Means are provided for enclosing the fuse holder except at one end thereof wherein the gas is dis-charged from the fuse holder through an opening at said one end. Means are also provided for closing the opening at said one end into a substantially enclosed chamber. The chamber receives the gas discharged from the fuse holder and the chamber has a thermal quenching medium disposed therein.

BRIEF DESCRIPTION OF THE DRAWING:

The advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description when taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a side view of a typical universal fuse link;

FIG. 2 provides curves illustrating the time-current characteristics of a typical expulsion fuse using a universal fuse, and a typical current-limiting fuse; and,

FIG. 3 illustrates a preferred embodiment of an expulsion fuse in accordance with the present invention.

DETAILED DESCRIPTION

Referring now to FIG. 1, there is shown a typical universal distribution fuse link of the type defined by the American National Standard Institution specification C 37.43-1969. The fuse link includes a button head cap 1 whose diameter varies in accordance with the continuous current rating of the fuse link. For example, in the range of 1–50 amperes, the diameter of button head cap 1 is defined as either one-half or three-fourths inch. In the range of 55–100 amperes, the diameter of button head cap 1 is specified as three-quarters inch, etc.

A typical fuse link such as fuse link 10 of FIG. 1 further includes a threaded member 2 which threadedly engages button head cap 1 on one end and a meltable or fusible element 3 on the other end. Meltable link 3 normally comprises a metallic element of reduced cross-section of another material such as copper, tin or silver. A mechanical strain wire 4, or a material such as stainless steel or other high melting temperature material, bridges fusible element 3 and thereby prevents separation until fuse link 3 has melted. A suitable member 5 accepts the lower ends of fusible element 3 and strain wire 4 at one of its ends and a flexible lead 6 at the other end. Flexible lead 6 normally comprises a bundle of stranded or braided fine copper wires. Finally, a typical universal distribution fuse link such as fuse link 10 of FIG. 1, normally includes a tubular member 7 which is fixedly mounted at one of its ends to member 2.

The tubular member is usually composed of fibrous organic material, such as a horn fiber or wrapped fish paper, and has an outside diameter which varies in accordance with the continuous current rating of the fuse link. For example, for current values between 1 and 50 amperes, the outside diameter of tubular member 7 must be such that the fuse link will freely enter a fuse holder having an inside diameter of five-sixteenths inch. Similarly, for current ratings between 55 and 100 amperes, the fuse link must freely enter a fuse holder having an inside diameter of seven-sixteenths inch. The function of tubular member 7 is to provide an arc-extinguishing or arc-responsive material to extinguish arcs under low current faults. That is, such a tubular member is necessary to extinguish low current arcs which would not be easily extinguished by the larger internal diameter of the fuse tube of the fuse holder.

Universal fuse links such as the type depicted in FIG. 1 are identified in accordance with two types. The first type is the type "K" for fast fuse links. Type "K" fuse links have a speed ratio of the melting time-current characteristics (that is, melting time to current rating) varying from 6 for the 6-ampere rating to 8.1 for the 200-ampere rating. In the second type or type "T", the speed ratio of the melting time-current characteristics vary from 10 for the 6-ampere rating to 13 for the 200-ampere rating. It should be noted that the terms "fast" and "slow" are used only to indicate the relative speeds of "K" and "T" fuse links.

As previously alluded to, an important consideration in the proper design of a power distribution system is that the various fuses and devices in the system exhibit coordination with respect to one another. In order for the various fuses of a given system to exhibit coordination, the time-current characteristics must be nearly identical. Turning now to FIG. 2, there is shown a graph of the time-current characteristics of a universal fuse link and a current limiting fuse. Curve A illustrates the time-current characteristics of a universal fuse link having a given continuous current rating. Curve B illustrates the time-current characteristics of a current-limiting fuse having a given continuous current rating. In FIG. 2, time is plotted along the ordinate whereas current is plotted along the abscissa. Thus, curves A and B illustrate the clearing time for various current levels. It can be seen that the total clearing time for both fuse A and B of FIG. 2 decreases with increasing current. It can also be seen that for currents less than 1, fuse A will clear before fuse B. Similarly, it can be seen that for currents greater than 1, fuse B will clear before fuse A. Consequently, these fuses do not coordinate throughout their full operating range, and, accordingly, should not be utilized in the same power distribution system. One problem occurred by such lack of coordination is that fuse A could clear before fuse B whereas fuse B may be the fuse closest to the fault or overload. This lack of-coordination problem is further complicated by the fact that the relative clearing times vary with respect to current load.

Thus, it should now be appreciated that proper power distribution system design requires that the various devices and fuses in the system exhibit coordination with respect to each other. Further, since the universal fuse links are by far the most prevalent in the industry, there exists a need for a fuse structure which can accommodate the universal fuse links, particularly
for underground applications and applications where non-violent operation is required or desired. Referring now to FIG. 3, there is shown a preferred embodiment of the present invention which I have chosen for illustration. In FIG. 3, an enclosed, non-vented explosion fuse structure 100 is shown in conjunction with a universal fuse link 102. Fuse structure 100 includes a generally tubular or cylindrical fuse holder 104. Fuse holder 104 includes a tube liner 106, preferably of organic material of the type wherein energy loss from an arc in the tube decomposes a portion of the tube liner into a turbulent, high-pressure, high-temperature permanent gas. Suitable materials for liner 106 include bone or horn fiber, and polyoxymethylene (acetal); however, equally successful results should be obtainable from tube liners composed of other known arc-extinguishing materials such as nylon, nylon with molybdenum disulfide, polymethylacrylate, boric acid, or other suitable arc-extinguishing materials known to the art.

It should also be appreciated that fuse holder 104 may be eliminated entirely if tube liner 106 is otherwise provided with a material of sufficient mechanical strength. In this case, fuse holder 104 itself provides a tube liner of arc-responsive material. Tube liner 106 and fuse holder 104 also function as suitable insulating materials to electrically isolate fuse terminals disposed on opposite ends of the fuse holder structure. The upper end (with respect to FIG. 3) of fuse holder 104 is suitably fastened to a cylindrical terminal member 108. The outer surface of terminal member 108 is provided with threads which threadedly engage the inner threads of a terminal cap 110. The dimension of terminal cap 110 is provided with sufficient height to securely fasten button head cap 112 of fuse 102 to terminal member 108. Terminal member 108 and terminal cap 110 also function to provide a gas-tight seal at the upper end of fuse holder 104, and means for providing an electrical connection to one end of fuse link 102.

A flexible lead 114 of fuse link 102 is routed externally of fuse holder 104 and suitably fastened to a lower terminal 116 as by way of fastening means 118. Lower terminal 116 also includes fastening means shown generally at 120 for coupling lower terminal 116 to an external circuit. Lower terminal 116 sealingly engages fuse holder 104 and threadedly engages an upper portion of encased chamber 122. The threaded engagement of lower terminal 116 to chamber 122 also provides a gas-tight seal. Disposed within chamber 122, there is provided a thermal quenching medium 124.

Quenching medium 124 may comprise any one of a number of suitable media or materials such as copper screen rolled into a cylindrical form steel screen alone or as provided with a nickel plating, palladium plated copper screen, etc. However, it should be appreciated that the medium 124 may also comprise other suitable materials including finely divided ceramic powders such as Al₂O₃ or SiO₂; or, small, specially-formed, non-compacting pieces of copper screen commonly known as "burl saddles." In operation, quenching medium 124 acts to absorb thermal energy from the energized gases impinging thereon and at a sufficiently fast rate to prevent thermal or mechanical damage to chamber 122. It should now be appreciated that fuse holder 104 is provided with means for enclosing the fuse holder except at a lower end thereof wherein gas is discharged from the fuse holder through the lower opening. It should also be appreciated that chamber 122 provides means for enclosing the lower opening of fuse tube 104 into an enclosed chamber which receives the gas discharged from fuse holder 104.

The operation of the enclosed, non-vented explosion fuse structure 100 of FIG. 3 is described as follows: It is assumed that fuse structure 100 is suitably connected between the line and load of a power distribution system by way of the terminals provided at opposite ends of fuse holder 104. Upon sensing an abnormal condition in current, such as an overload or high current fault, the fusible member of fuse link 102 melts or is vaporized and an arc forms in the resulting gap. The thermal energy loss from the arc decomposes a portion of the fuse tube liner 106 into a high-pressure, high-temperature turbulent gas, which, in turn, acts on the core of the arc to sufficiently cool and deionize the gap and thus effect circuit interruption at a current zero. At this time, the flexible lead 114 of fuse link 102 drops out from fuse holder 104 either due to the resulting gas pressure, or as assisted by an extractor spring (not shown).

The high-pressure, high-temperature gases resulting from the decomposition of the fuse tube liner are expelled and discharged out from fuse holder 104 into the quenching medium 124. Quenching medium 124 acts at a rate which is sufficient to quickly cool and drop the pressure of the gas before the gas can cause thermal or mechanical damage to the totally enclosed chamber 122.

It should now be appreciated that fuse structure 100 provides expulsion fuse operation within a totally enclosed or non-vented housing while using universal fuse links and which operates in a non-violent manner. It should be noted that although chamber 122 is illustrated as being totally enclosed, a pressure relief valve may be provided on a suitable surface of chamber 122 so as to bleed off any resulting residual gas pressure, once the fuse clears. Accordingly, the structure can be disassembled to facilitate the installation of a new fuse link without the presence of residual gas pressure which might otherwise endanger the operator. Further, in a given high-current application, it may be desirable to locate fuse link 102 within fuse holder 104 at a position other than that shown in FIG. 3. For example, a fuse link extender can be provided to lower the relative position of fuse link 102 within fuse holder 104. The extender may take the form of a rod having a diameter on the order of the fuse link and a threaded bore at one end to accept the threaded portion of member 2 of FIG. 1, and a threaded portion to engage button head cap 1 of FIG. 1. This fuse extender technique is known to the art of overhead cutouts, as exemplified in U.S. Pat. No. 2,816,979.

What has been taught, then, is a totally enclosed, non-vented expulsion fuse accommodating, notably, universal fuse links. This combination provides non-violent expulsion fuse operation and time-current characteristic coordination facilitating, notably, overhead-cutoff-type operation in a completely underground power distribution system.

What is claimed is:
1. An enclosed, non-vented explosion fuse structure for use with a fuse link of the type having a melting link surrounded by an integral tubular member of arc responsive material and wherein an arc is drawn in said
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7. The fuse structure according to claim 1, wherein said fuse holder comprises a generally tubular member of organic material.

8. The fuse structure according to claim 4, wherein said fuse holder is of a material of the type wherein energy loss from said arc decomposes a portion of said fuse holder into a turbulent, high-pressure, high-temperature gas, whereby said fuse holder incorporates said liner.

9. The fuse structure according to claim 5, wherein said fuse holder comprises a generally tubular member of organic material.

10. The fuse structure according to claim 5, wherein said fuse holder comprises a generally tubular member of organic material.