FUSE CONSTRUCTION HAVING A RESILIENT ROD INCLUDING A CONNECTION PROVIDED WITH MECHANICAL ADVANTAGE LEVERS AND A SPRING BUTTON

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This invention relates, generally, to electric circuit interrupters and it has particular relation to fuses of the current limiting type for use on circuits operating at various voltages such as of the order of 34.5 kV. This particular voltage is mentioned for illustrative purposes since the invention can be employed on systems operating at higher or lower voltages as may be desired.

Among the objects of this invention are: To provide a new and improved fuse of the suspension type that can be connected to and suspended from an electric power line conductor and directly connected to a terminal of a load device, such as a transformer; to employ for this purpose a current limiting fuse having a current limiting section in its upper end and a solid material section at its lower end, the sections being interconnected by a fusible element that restrains movement of a rod like terminal through a bore in the solid material section; to bias the rod like terminal by a spring for movement through the bore and to tension the fusible element with only a part of the biasing force being applied to the fusible element; to restrain a possible biasing action by clutching it to the housing or fuse tube of the current limiting fuse as long as the fusible element remains intact; to apply the entire biasing action to the rod like terminal on blowing of the fusible element for moving the rod like terminal through the bore to extend and extinguish the arc therein to ensure the rod like terminal from the fuse housing; to provide the restraint of the biasing action through mechanical advantage means reacting between the rod like terminal and the fuse tube and against a spring button that is biased outwardly by the fuse tube by a coil compression spring to connect the rod like terminal through the spring button to a cup shaped plug or disc that is slidably mounted in the lower end of the fuse tube with the connection between the spring button and the cup shaped plug or disc being a rigid connection; to interconnect the cup shaped plug or disc and a terminal of the load device by retractable flexible conductor means; and to provide the retractable flexible conductor means in the form of a helical coil of insulated stranded conductor with the convolutions surrounding a coil tension spring acting in a direction to collapse the convolutions of the helical coil.

In the drawings:

FIG. 1 is an elevational view showing a typical installation of a pair of suspension fuses, in which the present invention is embodied, connected between power line conductors and the terminals of a transformer mounted on a pole.

FIG. 2 is a view, in side elevation, of the construction shown in FIG. 1.

FIGS. 3A—3B—3C placed end to end in the order named show a longitudinal sectional view at an enlarged scale of the suspension fuse shown in FIGS. 1 and 2.

FIG. 4 is a horizontal sectional view, at an enlarged scale, taken generally along the line 4—4 of FIG. 3C.

FIG. 5 is a bottom plan view of one of the levers employed in the mechanical advantage means.

FIG. 6 is a horizontal sectional view taken generally along the line 6—6 of FIG. 3C at the same scale as FIG. 4.

FIG. 7 is a view, partly in side elevation and partly in section, showing details of construction of the flexible conductor connected to the lower end of the suspension fuse.

FIG. 8 is a view, similar to the lower end of FIG. 3C, showing a modified construction.

FIG. 9 is a sectional view taken generally along the line 9—9 of FIG. 8.

Referring now particularly to FIGS. 1 and 2 of the drawings, it will be observed that reference character 10 designates a support in the form of a wood pole from which cross members 11—11 extend for supporting a distribution transformer that is indicated, generally, at 12. The transformer 12 is provided with upstanding insulators 13—13 through which high voltage terminals 14—14 extend. It will be understood that the transformer 12 and parts associated therewith are illustrative of many different forms of transformer that can be employed in practicing the present invention.

Extending from the upper ends of the high voltage terminals 14—14 are terminal extensions 15—15 the outer ends 16—16 of which are arranged for receiving hot line clamps 17—17. It will be understood that the hot line clamps 17—17 are of the kind and character that can be manipulated by a hot line stick which is in conventional use by lineman for the purpose of working circuits that are energized or "hot." The hot line clamps 17—17 are employed for making connections to the outer ends 16—16 of the terminals extensions 15—15 by the lower ends of flexible conductors shown generally at 18—18. The flexible conductors 18—18 extend from the lower ends of suspension fuses that are indicated generally, at 19—19 which are provided with resilient conductors 20—20 preferably in the form of conductor rods, for example 7/64 in. diameter Phosphor bronze or hard drawn copper rods, which can be secured by a hot line clamp 21, FIG. 2, to a strainer section 22 that is connected to a high voltage conductor 23. As shown in FIG. 1 two conductors 23 are provided and they are mounted in conventional manner on insulators 24—24 that are carried at the ends of a cross arm 25. The arrangement shown in FIGS. 1 and 2 of the drawings is typical of a construction in which two suspension fuses 19—19 are employed, one for each line conductor 23 and between it and the respective high voltage terminal of the transformer 12. In some applications only a single suspension fuse 19 is employed and provision is made for grounding the other terminal 14 of the transformer 12.

FIGS. 3A—3B—3C show the details of construction of one embodiment of the suspension fuse 19. Here it will be noted that a fuse housing, in the form of a fuse tube 28, is provided and it is made of suitable insulating material such as glass reinforced epoxy tubular material. Other materials, such as a phenolic condensation product, can be used. At its upper end the fuse tube 28 is closed by an upper fuse plug 29 of conducting material that is held in place by retaining pins 30—30 which extend from diametrical positions on the fuse tube 28 into the body of the upper fuse plug 29. Annular grooves 29' are formed in the body of the upper fuse plug 29 to prevent capillary migration of water into the upper end of the fuse tube 25. A metal cap 31 overlies the upper end of the fuse tube 28 and the upper fuse plug 29. It is secured to the latter by brazing as at 32 and an upstanding section 33 extends therethrough which is brazed at 34 to the resilient conductor or rod 20 by means of which the fuse 19 is suspended from the strainer section 22 connected to the high voltage conductor 23 by the hot line clamp 21.

In the upper end of the fuse tube 28 there is positioned a current limiting section that is indicated, generally, at 35. It includes a terminal fitting 36 into which the lower end of the flexible conductor rod 20 is secured with a press
The terminal fitting 36 is located at the upper end of an insulating rod 37 which extends downwardly through the fuse tube 28 and has a spiral groove 38 in its surface in which a conductor 39, preferably of silver, is located. The upper end of the conductor 39 is connected to the terminal fitting 36 and thereby to the lower end of the conductor rod 26. The lower end of the conductor 39 is connected to a terminal fitting 40, similar to the terminal fitting 36, that extends into the lower end of the insulating rod 37. Insulating washers 41 are located in uniform spaced relation along the insulating rod 37 and the space therebetween surrounding the insulating rod 37 and the inner wall of the fuse tube 28 is filled with sand 42. In the event of flow of fault current sufficient to fuse the conductor 39, it is vaporized and distributed over the sand 42 with the result that relatively high resistance is inserted in the circuit and the magnitude of the fault current is correspondingly limited.

As shown in FIG. 3B a fusible element terminal 45 extends downwardly from the terminal fitting 40 at the lower end of the current limiting section 35. The fusible element terminal 45 extends through a vent washer 46 which is provided with openings 47 that permit venting of the interior of the current limiting section 35 which is desirable on vaporization of the conductor 39 under fault conditions. The sand 42 is prevented from escaping through the openings 47 by a screen 48 located on the upper side of the vent washer 46.

The lower end of the fusible element terminal 45 is connected to the upper end of a fusible element 49. In the embodiment shown the fusible element 49 comprises a single length of relatively high strength wire, such as wire formed of a nickel chromon alloy. This construction is employed where the continuous rating of the suspension fuse 19 is of the order of five amperes. Other fusible element constructions can be employed depending upon the current rating of the device. For some fusible elements a parallel fuse wire is provided for increasing the current rating.

The lower end of the fusible element 49 is connected to the upper end of a rod like terminal 51. It will be understood that the ends of the fusible element 49 are mechanically secured to the lower end of the fusible element terminal 45 and the upper end of the rod like terminal 51 with the arrangement being such that substantial force applied to the rod like terminal 51 is restrained thereby until the fusible element 49 is ruptured as by the flow therethrough of sufficient current to cause such action.

The rod like terminal 51 extends downwardly through a bore 52 that is formed in a stack of cakes 53 of suitable arc extinguishing material such as boric acid. It will be noted that the cakes 53 of solid arc extinguishing material and the rod like terminal 51 movable through the bore 52 therein form a solid material section, indicated generally at 54, at the lower end of the fuse tube 28. This section functions to interrupt the flow of fault current which is less than the current flow required to vaporize the conductor 39 of the current limiting section 35. The section 54 also includes the fusible element 49 which is located in a space between the current limiting section 35 and the solid material section 54 which is surrounded by a metallic corona shield 55. It is desirable to provide this construction since the diameter of the fusible element 49 is relatively large and the extinguishing effects of arc draught at high voltage would be likely to impair its accuracy if the corona shield 55 were not provided. It will be understood that the cakes 53 of solid arc extinguishing material are held in place within the lower end of the fuse tube 28 by a suitable layer of epoxy resin (not shown) which is applied in a liquid form and is prevented from flowing out of the upper end of the space therebetween by an O ring 56 of rubber like material. Subsequently the epoxy resin sets to provide an integral construction. A metallic washer 57 overlies the uppermost cake 53 in the solid material section 54 and the upper end of the rod like terminal 51 projects through an enlarged opening therein.

Referring now to FIG. 3C of the drawings, it will be noted that a fiber washer 60 is located beneath the lowermost cake 53 of solid arc extinguishing material and that the lower end of the rod like terminal 51 extends therethrough and through a metallic sleeve 61 that is secured at its lower end to a spring button 62 that is formed of good conducting material such as copper. A coil compression spring 63 reacts between the underside of the washer 60 and an upwardly facing shoulder 64 extending along the periphery of the spring button 62. The spring 63 is provided for applying a tension force to the rod like terminal 51 that is restrained, in part, by the fusible element 49.

In order to relieve the fusible element 49 of a substantial portion of the biasing action provided by the coil compression spring 63 mechanical advantage means are provided.

The mechanical advantage means includes levers 65—65 that are pivoted intermediate their ends on a circular shoulder 66. FIG. 4, which is located between a flat annular surface 67 on the underside of the spring button 62 and an inclined annular surface 68 that extends to the periphery of the shoulder 66. The outer ends 69—69 of the flat or leaf like levers 65—65 extend into an annular groove 70 that opens inwardly of the fuse tube 28 at a location spaced slightly from its lower end. It will be noted that the outer ends 69—69 of the levers 65—65 react against a lower shoulder 71 on the fuse tube 28 which forms the lower side of an annular groove 70. A split wire ring 72 is positioned along the shoulder 71 to provide a smooth hard reaction surface for the undersides of the outer ends 69—69 of the levers 65—65. The inner ends 73—73 of the levers 65—65 have semi-circular openings 74, FIG. 5, to permit the lower end of the rod like terminal 51 to extend therethrough. These bifurcated ends 73—73 react against abutment means in the form of a nut 75 that is adjustable on threads 76 at the lower end of the rod like terminal 51. In FIG. 3-C of the drawings the upper side of the nut 75 is shown in spaced relation to the bifurcated inner ends 73—73 of the levers 65—65 for the purpose of disclosing the details of construction more clearly. When finally assembled for use the nut 75 is forced along the levers 65—65 to provide a predetermined space or clearance 77 between the upper surfaces of the bifurcated ends 73—73 and the flat annular surface 67. The purpose of this arrangement is to permit the levers 65—65 to rock about the circular shoulder 66 on the underside of the spring button 62 when the fusible element 49 blows and the rod like terminal 51 is released for downward movement under the influence of the coil compression spring 63 which has the necessary tension to withdraw the rod like terminal 51 particularly under low fault current conditions. However, only a portion of the biasing force exerted by the spring 63 is restrained by the fusible element 49 because of the provision of the levers 65—65 and the proportions thereof with respect to the fulcrum provided by the circular shoulder 66. The relatively low tension applied to the fusible element is desirable in order to permit the tension to be more predictable and to cause it to blow within an easily predeterminable time current relationship. The upper end of the rod like terminal 51 has a portion of the force exerted by the spring 63 directly to the fuse tube 28 through the split wire ring 72 and apply it to the lower shoulder 71. When the fusible element 49 blows, the inner ends 73—73 of the levers 65—65 are no longer restrained and they rock about the circular shoulder 66 into the slotted arc extinguishing material 53 to an extent sufficient to clear the lower shoulder 71. This permits them together with the spring button 62, sleeve 61, spring 63 and rod like terminal 51 to move out of the lower end of the fuse tube 28.
this takes place anywhere a rod drawn between the lower end of the fusible element terminal 45 and the upper end of the rod like terminal 53 is extended into the bore 52 from the walls of which an arc extinguishing medium is evolved that assists in extinguishing the arc.

The lower end of the fuse tube 28 is closely by a cup shaped bottom fuse plug 78 of conducting material. The fuse plug 78 opens into the interior of the fuse tube 28 and is slidably mounted therein for expulsion along with the spring button 62 and parts associated therewith on blowing of the fusible element 49. Annular grooves 79—79 are formed in the exterior of the wall of the fuse plug 78 to prevent capillary migration of water into the lower end of the fuse tube 28. Milled slots 80—80 in the upper end of the fuse plug 76 permit it to extend beyond the outer ends 69—69 of the levers 65—65 and to bear against the inclined surface 68 of the spring button 62. Suitable screws 81—81, FIGS. 4, 6 and 7, extend through the bottom of the fuse plug 78 and into the spring button to hold the former against the latter so that a direct mechanical and electrical connection is provided therewith. Edges 82—82 along the inner side of the lower ends of the slots 80—80 in the fuse plug 79 bear against lever buttons 83—83 which extend downwardly from the levers 65—65 at a location where the circular shoulder 66 is located centrally thereof. The lever buttons 83—83 prevent the outer end 69—69 of the levers 65—65 between the peripheries of the spring button 62 and the lower shoulder 71 since these buttons are held within the confines of the upper end of the fuse plug 78. If this construction were not provided, there might be interference with the expulsion of the spring button 62 on blowing of the fusible element 49 and release of the spring 63.

The bottom of the fuse plug 78 is provided with a central opening 84 through which the upper end of a tubular terminal 85 extends and which is turned over, as indicated at 86, to provide a good electrical and mechanical connection thereto. A stranded conductor 87 extends through the tubular terminal 85 which is deformed, as indicated at 88, to provide a good electrical and mechanical connection thereto. The tubular terminal 85 has a hollow end 89 which is deformed at 90 intermediate its ends to insulating covering 91 and extends down the stranded conductor 87 except for the bored ends thereof.

In order to facilitate replacement of a fuse 19 with safety after it has blown, to accommodate variations in distance between the lower end of the fuse tube 28 and the upper end of the respective terminal extension 15 or equivalent part, and to have in other installations a minimum of dangling, the flexible conductor 18, shown in FIG. 7, includes a helical coil 92. It will be understood that the stranded conductor 87 with its insulating covering 91 is wound into this form so that the convolutions thereof are next to each other, the arrangement being such that they are normally held in the collapsed position by a coil tension spring 93 which is located within these convolutions and which has sufficient tension to support the hot line clamp 17. One end 94 of the internal spring 93 is connected or anchored to the adjacent end of the helically coiled section 92 while the other end 95 is similarly anchored to the other end. It will be understood that the spring 93 acts to bias the turns of the helical coil 92 to the collapsed position as shown in FIG. 7 and also in the unattached position shown to the left side of FIG. 1. The extended position is shown in the connected arrangement illustrated at the right of FIG. 1.

The terminal 97 is located on the outer end of the flexible conductor 18. As shown in FIG. 7, it is deformed at 98 into the insulating covering 91 and at 99 onto the strands of the conductor 87 to provide intimate mechanical and electrical engagement therewith. The tubular terminal 97 facilitates application of the hot line clamp 17 thereto.

It will be understood that additional tension or downward force is applied to the spring button 62 by the coil tension spring 93 over that provided by the coil compression spring 63. However, as pointed out above, only a portion of this combined tension is applied to the rod like terminal 51 to be restrained by the fusible element 49. When the fusible element 49 blows, the rod like terminal 51 is no longer held against movement by the mechanical advantage means as described above. On release of the rod like terminal 51, the inner ends 73—73 of the levers 65—65 no longer are restrained and they rock about the circular shoulder 66 with the ends 69—69 moving toward the inclined annular surface 68 and out of restraining engagement with the split wire ring 72 on the shoulder 71. The combined forces exerted by the springs 63 and 93 acting through the spring button 62 cause it to move downwardly until further restrained by the upper surface of the nut 75 with the inner ends 73—73 of the levers 65—65 therebetween. The net result of the forces released is to apply them wholly to the expulsion of the rod like terminal 51 together with the spring 63, 65, 71 of the annular cup shaped bottom fuse plug 78. The flexible conductor 18 then swings downwardly from the outer end 16 of the respective terminal extension 15 and a substantial space is provided between the lower end of the fuse tube 28 and the outer end 16 of the respective terminal extension 15. By suitable manipulation by a hot line stick, the hot line clamp 17 and 21 are released and the fuse parts connected thereto are removed from the circuit. Afterward, as will be readily understood, an unblown suspension fuse 19 is applied to replace the blown fuse.

FIGS. 8 and 9 show a modified form of the construction at the lower end of the fuse tube 28. Here it will be observed that a spring button 102 is provided which corresponds to the spring button 62 shown in FIG. 3—C and described hereinafter. The spring button 102 has an upwardly facing annular shoulder 103 against which lower end of the coil compression spring 63 reacts. On its under side the spring button 102 has an apertured cylindrical boss 104 which extends into a cylindrical opening 105 in a lever saddle 106. It will be noted that the lever saddle 106 has a flat bottom section 106' the upper side of which engages the lower side of the spring button 102 flatwise. The flat bottom section 106' has flat walls 107—107 which are provided with downwardly facing furcular grooves 108—108 in which laterally extending trunnions 109—109 from levers 110—110 are pivoted. The levers 110—110 are formed of Phosphor bronze strip material and are of plate like configuration. The lever saddle 106 is formed of yellow brass sheet having the sidewalls 107—107 bent from the flat bottom section 106'.

The inner and outer ends of the levers 110—110 are mounted in a manner similar to the mounting of the levers 65—65 previously described. Here the outer ends 111—111 of the levers 110—110 bear against the split wire ring 72 which overlies the lower shoulder 71 of the annular groove 70. The inner ends 112—112 of the levers 110—110 are aranged to react against the upper side of the nut 75 which constitutes abutment means and is threaded on the lower end of the rod like terminal 51. In FIG. 8 the nut 75 is shown in spaced relation below the inner ends 112—112 of the levers 110—110 to show more clearly the details of construction. On assembly the nut 75 is tightened on the threaded lower end of the rod like terminal 51 until its upper side engages the inner ends 112—112 of the levers 110—110, in such manner as to leave a small clearance 113 between the upper sides of the inner ends 112—112 and the under side of the cylindrical boss 104 through which the rod like terminal 51 extends. When the fusible element 49 blows and the rod like terminal 51 is released, the coil compression spring 63 no longer is restrained by the levers 110—110. As a re-
sult the spring button 102, the lever saddle 106 and the levers 110—110 are expelled from the lower end of the fuse tube 28 along with the coil compression spring 63 and rod like terminal 51.

In the construction shown in FIG. 8, the lower end of the fuse tube 28 is closed by a closure disc 115 that may be formed of yellow brass sheet and is of such a diameter that it fits loosely within the lower end of the fuse tube 28. The closure disc 115 has a central opening 116 for receiving the upper end of the tubular terminal 85 with its upper end turned over as indicated at 86 to provide a good mechanical and electrical connection thereto. The tubular terminal 85 has the stranded conductor 87 extending therethrough and it is deformed at 88 to provide a good electrical and mechanical connection therewith. The lower hollow end 89 of the terminal 85 is deformed at 90 on to the insulating covering 91 which surrounds the stranded conductor 87 all as described hereinafter.

In order to interconnect electrically and mechanically the closure disc 115 with the spring button 102, screws 117—117 extend through clearance openings in the disc 115 and are threaded into the spring button 102. Spacing sleeves 118—118, interposed between the upper side of the closure disc 115 and the under side of the spring button 102, permit the screws 117—117 to be tightened and therewith provide a rigid structure with the closure disc 115 being spaced a fixed distance below the spring button 102.

In FIG. 9 the screws 117—117 are shown as being located on opposite sides of the lever saddle 106. This shows their actual location while FIG. 8 shows them shifted through 90° in order to illustrate the arrangement more clearly.

What is claimed as new is:

1. A fuse for suspension from an electric power transmission conductor comprising, in combination,
   (a) a fuse tube,
   (b) a resilient conductor secured at its lower end to the upper end of said fuse tube and extending upwardly therefrom for connection at its upper end to said conductor,
   (c) a current limiting section in the upper end of said fuse tube connected to said lower end of said resilient conductor,
   (d) a solid material arc extinguishing section in said fuse tube below said current limiting section having a longitudinal bore from which an arc extinguishing medium is evolved due to the heat of an arc,
   (e) a rod like terminal slidably mounted in and extending out of the lower end of said bore from the upper end of which an arc is drawn in said bore,
   (f) a fusible element interconnecting said current limiting section and said upper end of said rod like terminal,
   (g) a spring button slidably mounted in said fuse tube in spaced relation to the lower end of said arc extinguishing section,
   (h) spring means biasing said spring button outwardly of the lower end of said fuse tube,
   (i) mechanical advantage means operatively interconnecting said spring button and the lower end of said rod like terminal whereby said spring means is restrained by said fusible element and only a portion of the force exerted by said spring means is applied to said fusible element, and
   (j) conductor means connected to said spring button and extending from said lower end of said fuse tube and moveably outwardly thereof together with said rod like terminal on blowing of said fusible element.

2. The invention, as set forth in claim 1, wherein the conductor means connected to the spring button includes:
   (a) a closure member slidably mounted on the lower end of the fuse tube,
   (b) connecting means between said closure member and said spring button, and
   (c) a flexible conductor connected to said closure member.

3. The invention, as set forth in claim 2, wherein the flexible conductor connected to said closure member includes:
   (a) a helical stranded conductor, and
   (b) a coil tension spring within the convolutions of said stranded conductor acting in a direction to collapse the same.

4. The invention, as set forth in claim 3, wherein the helical stranded conductor extends through a helical insulating covering.

5. The invention, as set forth in claim 1, wherein the mechanical advantage means includes:
   (a) abutment means on the lower end of the rod like terminal, and
   (b) lever means pivoted on the spring button, reacting against said abutment means at one end, and reacting against a shoulder on the fuse tube at the other end.

6. The invention, as set forth in claim 5, wherein the abutment means includes a nut threaded on the lower end of the rod like terminal whereby the space between the lever means and the spring button adjacent said rod like terminal is adjustable.

7. The invention, as set forth in claim 5, wherein the lever means includes a pair of levers extending from opposite sides of the rod like terminal, each pivotally mounted intermediate its ends on the underside of the spring button with one end of each reacting against the upper side of the abutment means, and the other end of each reacting against the lower surface of an annular groove in the fuse tube.

8. The invention, as set forth in claim 7, wherein:
   (a) the conductor means connected to the spring button includes:
      (1) a cup shaped plug slidably mounted in the lower end of the fuse tube with the cup opening inwardly of said fuse tube, and
      (2) connecting means between said cup shaped plug and said spring button; and
   (b) each lever has a depending shoulder engaging the upper end of said cup shaped plug.

9. The invention, as set forth in claim 5, wherein:
   (a) a lever saddle is positioned on the underside of the spring button, and
   (b) the lever means includes a pair of levers having laterally extending trunnions pivoted on said lever saddle with one each of each lever reacting against the upper side of the abutment means and the other end of each lever reacting against the lower surface of an annular groove in the fuse tube.

10. The invention, as set forth in claim 9, wherein the lever saddle has:
    (a) a flat bottom section lying flatwise against the spring button,
    (b) walls depending from opposite sides of said flat bottom section, and
    (c) trunnion receiving grooves in the undersides of said walls.

11. The invention, as set forth in claim 1, wherein the conductor means connected to the spring button includes:
    (a) a disc slidably mounted in the lower end of the fuse tube, and
    (b) connecting means between said disc and said spring button.

12. The invention, as set forth in claim 11, wherein the connecting means includes a pair of screws extending through tubular spacers between the disc and the spring button.

No references cited.