

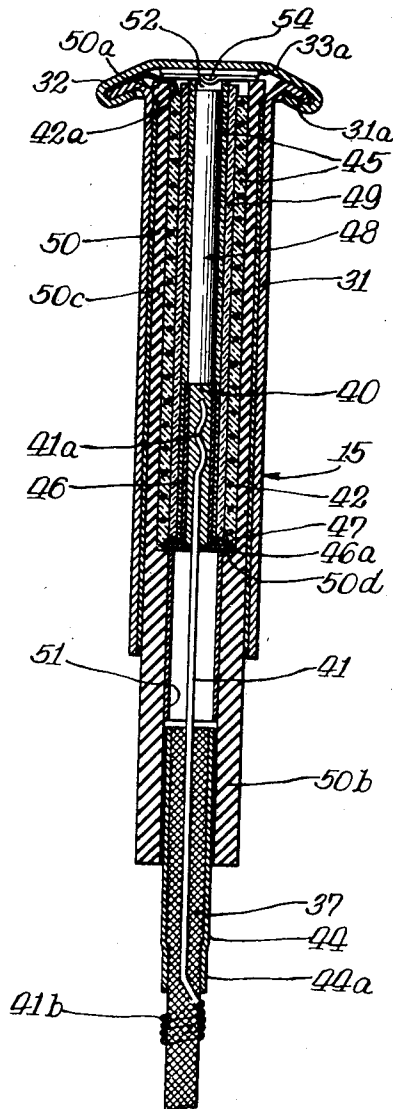
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FUSE LINK

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FUSE LINK

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The present invention relates to fuse links and more particularly to improvements in fuse links of the character disclosed in applicant's copending applications Serial No. 514,030, filed December 13, 1943, Serial No. 533,824, filed May 3, 1944, and Serial No. 637,528, filed December 28, 1945, all assigned to the same assignee as the present invention.

It is an object of the present invention to provide an improved fuse link of simple construction which provides long time overload protection, short time transient overload protection and is self-protected against damage due to lightning surges and the like.

In accordance with a further object of the invention, improved and exceedingly simple facilities are provided in the link for protecting the link against burn-out or damage when subjected to lightning surges or the like.

The present invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings in which the single figure is a fragmentary sectional view illustrating a fuse link characterized by the features of the present invention.

Referring now more particularly to the drawing, the present improved fuse link 15 is there illustrated as comprising a tubular metal casing 31 having an open lower end and a flanged upper end which is closed by a terminal cap 32.

The construction and mode of operation of the fuse link components provided within the metallic casing 31 are substantially the same as disclosed and claimed in applicant's co-pending application Serial No. 637,528, filed December 28, 1945, and assigned to the same assignee as the present invention, with the important exceptions pointed out below. This casing 31 houses three fusible elements 40, 41 and 42 which are connected in series circuit relationship between the casing 31 and the pigtail conductor 37. The two elements 41 and 42 are both formed of Nichrome wire or another metal wire or ribbon of the desired resistivity and are both of the same cross sectional area, such that they possess substantially identical time-current fusing characteristics. The fusible element 41 is substantially straight throughout the major portion of its length and the lower end portion thereof is centrally disposed within the upper end portion of a stranded pigtail conductor 37, the overlapping portions of the two elements 41 and 37 being telescoped within a

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metal assembly sleeve 44. This sleeve is crimped adjacent the lower end thereof, as indicated at 44a, and the lower end of the fusible element 41 is brought out through the strands of the conductor 37 and wrapped around the conductor 37 as indicated at 41b. After the three elements 41, 37, and 44 have been assembled to occupy the relative positions illustrated, the crimp 44a may be formed around the lower portion of the sleeve 44 for the purpose of providing a rigid mechanical connection between the three named parts. Thereafter, the lower end portion of the sleeve 44, the adjacent portion of the pigtail conductor 37 and the wrapped end portion 41b of the fusible element 41 may be soldered to provide a rigid connection therebetween.

The fusible element 42 may more properly be designated a combination impedance element and heating element in that it functions in conjunction with the improved surge gap facilities described below to prevent surge currents of large magnitude from traversing itself and also acts to heat the fusible element 40 to a fusing temperature when the link is subjected to an overload current for a sustained time interval. In order to perform these two functions the element 42 is constructed in the form of a helically coiled conductor, and the upper end portion 42a thereof is electrically and mechanically connected to the under side of the contact head 32 by crimping the same between the flange 31a and the cap 32.

The convolutions of the element 42 are spaced apart axially of the tube 31, and the spaced apart relationship between the turns is maintained by embedding the same in a body of dielectric refractory material 45. This body is preferably formed of a refractory cement and serves several functions which are pointed out with particularity below. It may, for example, be formed of Portland cement or any ceramic material which is chemically inert, has high specific heat, and is possessed of good electrical insulating properties. In order to increase the inductance of the element 42, thereby to enhance the surge current blocking function thereof, particles of magnetic material, such, for example, as iron powder or magnetite, may be disposed throughout the body 45, but in no case should the density of the magnetic particles be such as to provide conductive paths capable of short-circuiting the convolutions of the element 42. Among other functions, the body 45 serves rigidly to position or support the turns of the element 42 within the tube 31, and to this end entirely fills the upper portion of the tube. It also serves to support a tubular con-

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 ductor 40 centrally of the tube 31, this element being utilized in the connection of the fusible element 41 with the lower end portion of the combination heating and inductance element 42. More specifically, the upper tubular portion of the connecting element 46 is projected well within the turns of the element 42 in spaced apart relationship therefrom, and is embedded in the body 45. At its lower end this connecting element is provided with an outwardly extending flange 46a which serves to seat the lower turn of the element 42 in a manner such that the tubular portion of the element 46 is substantially concentrically disposed within the turns of the element 42. This lower turn of the element 42 is electrically and mechanically connected to the flanged portion 46a of the element 46 by means of a high melting point solder 47, or the like. The upper end of the connecting element 46 is electrically and mechanically connected to the upper serpentine end 41a of the fusible element 41 through the fusible element 40, the latter element being in the form of a body of alloy solder having a melting point of approximately 365° F. It is to be noted that the fusible element 40, as thus formed within the tubular portion of the connecting element 46, is disposed well within the turns of the element 42 so that heat generated by current conduction through the latter element may be transferred to the fusible element 40 through that portion of the refractory body 45 which separates the fusible element 40 from the adjacent turns of the element 42. Spring tension imposed upon the free lower end of the pigtail conductor 37 may be utilized to rapidly withdraw the end 41a of the fusible element 41 from the connecting element 46 when the named fusible element is heated to a melting temperature, and to widen a break in the fusible element 41 occasioned by heating this element to a fusing temperature.

For the purpose of increasing the heat storage capacity of the structure including the fusible element 40, a thermal storage element 48 is provided which is arranged in heat transfer relationship with the element 40 and the heating element 42. This element is in the form of a copper or brass rod disposed centrally of the tubular casing 31 and having its lower end contacting the exposed upper surface of the fusible element 40. It is held in an upright position in axial alignment with the tubular conductor 46 by virtue of its being embedded in the body 45.

During prolonged use of the link, the upper portion of the fusible element 40 may many times be heated to a fluid state without actual rupture of the element due to lack of persistence of the current overload responsible for the excessive heat energy. Also repeated heating and cooling of the body 45 may result in the formation of small interstices therein through which the fluid metal could be dispersed to short-circuit the lower convolutions of the coiled conductor 42. This would result in undesired modification of the time-overload characteristic of the link. In order to obviate this possibility, a ceramic insulating tube 49 is provided as a barrier between the parts 40, 46, and 48 and the turns of the coiled conductor element 42. Specifically, this tube is telescoped over the tubular conductor 46 to rest upon the flange 46a and is embedded in the body 45 in the manner illustrated. Being of heat resistant ceramic material, the tube 49 is not subject to cracking and hence acts as a leak-proof barrier between the fusible element 40 and the convolu-

tions of the coiled conductor element 42. Also, since the tube 49 has approximately the same heat transfer characteristics as the body 45, its presence in the zone of heat transfer between the elements 40 and 48 and the element 42 does not seriously complicate the problem of producing links having substantially the same time-overload characteristics in production quantities. Further, provision of the tube 49 in the structure facilitates assembly of the component elements of the structure in the manner explained below.

In order to maintain the turns of the element 42 out of contact with the metal casing 31, to maintain the element 41 out of contact with the tubular casing 31 and to provide a support for the surge gap facilities described below, the entire assembly within the casing 31 and a part of the sleeve 44 are surrounded by a tube 50 formed of Bakelite or other suitable insulating material. At its upper end, this tube is provided with a flange 50a pressed against the metal casing flange 31a when the cap 32 is fastened to the flange 31a. This tube 50 fits snugly within and is adhesively bonded to the tubular member 31, and the lower end portion 50b thereof projects outwardly from the open lower end of the casing 31. It is counterbored from the upper end to provide a first portion 50c of large internal diameter for receiving the parts 42, 45, 46, 48 and 49, and a second portion 50b of smaller internal diameter for receiving the fusible element 41. The flange 46a of the tubular conductor 46 is seated upon the step 50d between these two portions of the tube 50.

In order to assist in producing arc extinction within the tube 50 when the link is ruptured either through fusing of the element 40 or fusing of the element 41, that part of the tube portion 50b through which the fusible element 41 extends may be lined with a gas evolving material 51. Preferably, this lining is in the form of a layer of long fiber cellulose adhesively secured to the inner surface of the tube portion 50b between the flange 50d and the upper end of the sleeve 44 to surround the fusible element 41.

In accordance with the present invention, in order to prevent lightning surges from rupturing the fusible heating element 42, a surge gap having relatively immovable electrodes is connected in shunt with this element. Specifically, the heat storage element 48 having its lower end in electrical and mechanical contact with the upper end of the fusible body 40, is provided with an upper end which is spaced apart from a member 52 associated with the cap assembly 32 in a manner so as to define a small air gap 53 between the member 52 and the adjacent end of the heat storage member 48. This gap in combination with the storage element 48 and the fusible body 40 provides a surge path in shunt with the heating element 42 for by-passing surges around this element.

In considering the mode of operation of the fuse link 15, it may be assumed that the transformer which the link protects is provided with a low voltage secondary load which under normal conditions approximates the full load capacity of the transformer, and that this secondary load includes motors and other devices which, during the starting periods thereof, are capable of producing heavy transient currents of relatively short duration in both the primary and secondary windings of the transformer. In this regard, it will be understood that due to the heat radiating capabilities of the transformer parts, the transformer

may be capable of withstanding an overload current of reasonable magnitude, such, for example, as 200 to 300 per cent, for a relatively long time interval; whereas it can withstand current of the order of 500 per cent of normal for only a short time interval. It will also be understood that the transformer is capable of being damaged by a sustained increase in the voltage applied thereto.

The fuse link 15 operates to protect the transformer against damage occasioned by overload currents caused by any one of the mentioned factors. At the same time, the fuse link permits the transformer to be operated under sustained overload current conditions for a period less than that required to damage the transformer, and will not rupture when subjected to the normal and non-injurious high currents which are produced incident to motor starting, or the like. In this regard it will be understood that since the three serially related elements 40, 41 and 42 of the link 15 are traversed by the current flowing through the primary winding of the transformer, they are all heated by current conduction and the temperature of each element varies with changes in the magnitude of this current. The fusible element 40 is also heated by the heat conducted thereto from the element 42 through the walls of the connecting element 46. Heat energy is also transferred from the turns of the element 42 to the fusible element 40 through that portion of the refractory body 45 and the tube 49 which are disposed between the tubular portion of the connecting element 46 and the surrounding turns of the element 42, and also from the thermal storage element 48. Under constant load current conditions and with a constant voltage so long as the load current through the secondary winding of the transformer does not substantially exceed the full load capacity of this transformer, the fusible element 40 is operated at a temperature well below that required to produce fusion thereof. When, however, the secondary load current of the transformer gradually rises and is sustained for a period approaching that at which the transformer will be damaged, the temperature of the fusible element 40 is raised accordingly. Thus, as the load current increases, the current traversing the three elements 40, 41 and 42 is correspondingly increased so that more heat is produced in the fusible element 40 by current conduction. Concurrently the amount of heat conducted to this fusible element from the fusible elements 41 and 42 is increased. Also concurrently, the amount of heat transferred from the turns of the element 42 to the fusible element 40 through the refractory body 45 and the tube 49 is increased. A portion of the heat energy accumulating in the element 40 is transferred to the storage element 48 by conduction. After a predetermined time interval, required for the accumulation of heat within the fusible element 23, this element is heated to its fusing temperature and melts. Provision of the storage element 48 materially increases this time interval over that which would obtain in the absence of this element in the combination. When the element 40 is thus ruptured, the fusible element 41, the sleeve 44, and the upper end of the pigtail conductor 37, are quickly expelled from the lower end of the tube 50, thereby rapidly to break the circuit for energizing the primary winding of the transformer.

During the described separation of the element 41 from the tubular conductor 46 upon fusing of the element 40, an arc is drawn within the portion 50b of the tube 50. This arc instantly heats the

coating 51 to gas evolving temperature, with the result that gases are evolved therefrom which accelerate extinction of the arc. It has been found that provision of the gas evolving coating 51 permits the link itself to effectively extinguish heavy current arcs of the order of several hundred amperes even when the link is used in high voltage circuits of several thousand volts.

To consider the action of the fuse link 15 further, it may be pointed out that the refractory body 45 and the tube 49 prevent the fusible element 40 from being heated to its melting temperature when surge currents are produced in the primary circuit of the transformer as a result of motor starting or the like. Such surge currents are of short duration, being of the order of only a few seconds. The resulting momentary increase in heat generation within the fusible element 40 is wholly insufficient to raise the temperature of the element to its melting point. Moreover, those portions of the refractory body 45 and the tube 49 which are disposed between the tubular portion of the connecting element 46 and the storage element 48 and the turns of the heating element 42 dissipate a large portion of the heat resulting from the current surge through the element 42 away from the element 41. They also delay the transmission of the increased increment of heat produced by the element 42 to the storage element 48 and the adjacent walls of the connecting element 46 for an interval which will normally exceed the duration of the current transient. Accordingly, the increased increment of heat energy arriving at the surfaces of the connecting element 46 and storage element 48 from the element 42 as a result of the momentary high current, effects an insufficient increase in the temperature of the fusible element 40 to cause this element to melt. In other words, the total heat accumulated in the fusible element 40 as a result of the transient high current is insufficient to heat this element to its fusing temperature. Thus it will be understood that the refractory body 45 and the tube 49, or more exactly the thermal impedance of this composite structure, protects the fusible element 40 against outages occasioned by transient currents of the character which frequently occur in the load pattern of any transformer secondary load. This is accomplished, moreover, without increasing the thermal capacity of the fusible element 40 to a point such that it will provide no protection for sustained overload currents.

The thermal impedance of the refractory body 45 and the tube 49 also prevents the fusible element 40 from immediately rupturing when the transformer is subjected to a high current, such, for example, as that which is produced when the secondary winding of the transformer is short-circuited. In the absence of an additional protective element, therefore, the transformer could easily be damaged by an overload current of this character during the period required to transfer sufficient heat from the heating element 42 to the fusible element 40 to cause the latter element to melt. The second fusible element 41 functions to guard the transformer against damage when subjected to an overload current of this type. Thus, immediately the element 41 is subjected to a transient current of the particular character just referred to, a portion thereof lying between the upper end of the sleeve 44 and the lower end of the fusible element 40 is heated to a fusing temperature, permitting this element to rupture.

While there has been described what is at pres-

ent considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. A fuse link comprising a tubular metal casing open at one end and having a terminal cap closing the other end, an insulating tube fitting within and extending through said casing, a coiled heating conductor disposed within said tube and having its convolutions spaced axially of said tube, a tubular conductor extending within the convolutions of said coiled conductor to receive heat from said coiled conductor, said heating conductor being connected in series between said tubular conductor and said casing, a fusible body filling at least a portion of said tubular conductor, a circuit conductor having an end embedded in said fusible body and extending out of said insulating tube, an elongated and conductive heat storage element in heat transfer relationship with said fusible body and extending through the convolutions of said heating conductor toward said terminal cap, means including said heat storage element for defining within said tube a surge gap shunting said heating conductor, and insulating means disposed within said insulating tube to insulate said tubular conductor and said heat storage element from the convolutions of said heating conductor.

2. A fuse link comprising a tubular metal casing open at one end and having a terminal cap closing the other end, an insulating tube fitting within and extending through said casing, a coiled heating conductor disposed within said tube and having its convolutions spaced axially of said tube, a tubular conductor extending within the convolutions of said coiled conductor to receive heat from said coiled conductor, said heating conductor being connected in series between said tubular conductor and said casing, a fusible body filling at least a portion of said tubular conductor, a circuit conductor having an end embedded in said fusible body and extending out of said insulating tube, an elongated and conductive heat storage element in heat transfer relationship with said fusible body and extending through the convolutions of said heating conductor toward said

terminal cap, said heat storage element being electrically connected with said fusible body at one end and having its opposite end spaced from said terminal cap to define a surge gap shunting said heating conductor, and insulating means disposed within said insulating tube to insulate said tubular conductor and said heat storage element from the convolutions of said heating conductor.

3. A fuse link comprising a tubular metal casing open at one end and having a terminal cap closing the other end, an insulating tube fitting within and extending through said casing, a coiled heating conductor disposed within said tube and having its convolutions spaced axially of said tube, a tubular conductor extending within the convolutions of said coiled conductor to receive heat from said coiled conductor, said heating conductor being connected in series between said tubular conductor and said casing, a fusible body filling at least a portion of said tubular conductor, a circuit conductor having an end embedded in said fusible body and extending out of said insulating tube, a second tube of insulating material telescoped over said tubular conductor within said coiled conductor to insulate the convolutions of said coiled conductor from said tubular conductor and said fusible body, and an elongated and conductive heat storage element in heat transfer relationship with said fusible body and extending through said second tube toward said terminal cap, said heat storage element being electrically connected with said fusible element at one end and having its opposite end spaced from said terminal cap to define a surge gap shunting said heating conductor.

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