April 28, 1942. G. L. CARLISLE ET AL 2,281,266

CIRCUIT INTERRUPTER

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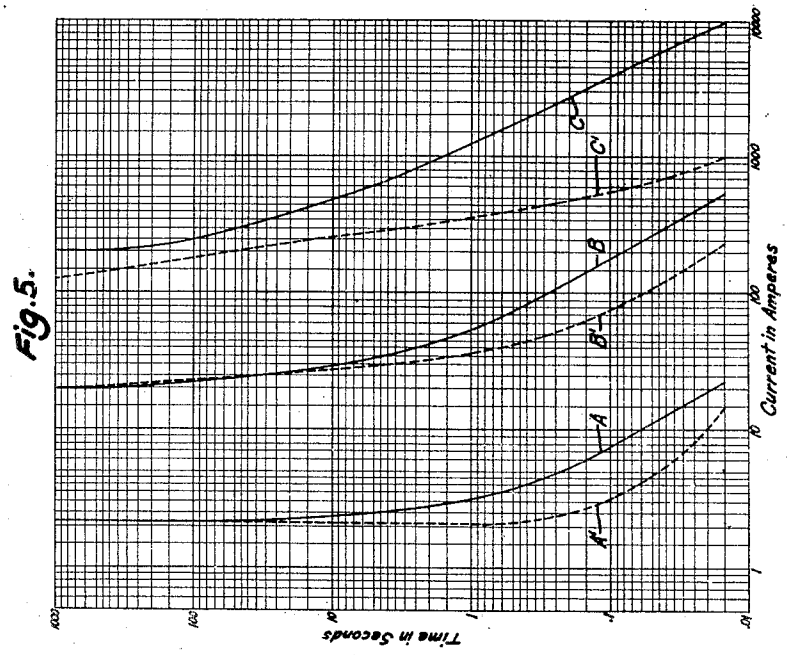


Fig. 5.

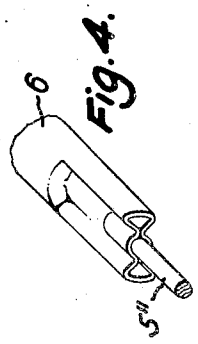


Fig. 4.

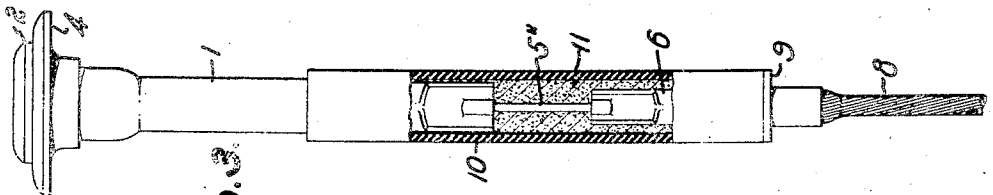


Fig. 3.

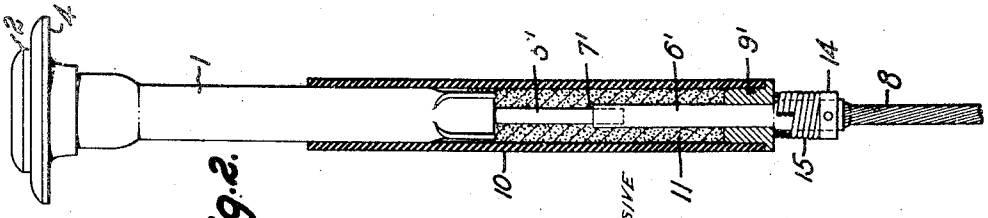


Fig. 2.

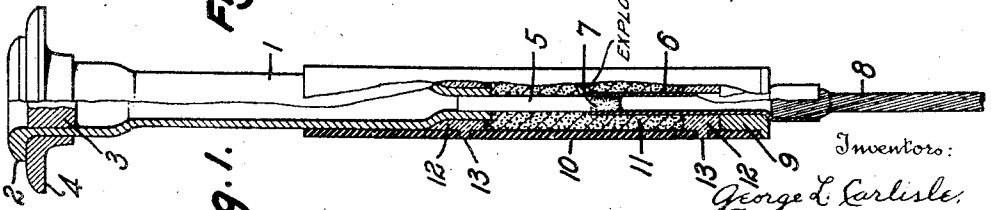


Fig. 1.

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CIRCUIT INTERRUPTER

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Application January 31, 1940, Serial No. 316,678

9 Claims. (Cl. 200—135)

This invention relates to circuit interrupters and particularly to overload circuit interrupters of the type in which the circuit-opening action is initiated by the thermal effect of the abnormally high current and the actual separation of the conductive elements is effected by a small powder charge.

This application is a continuation-in-part of our application Serial Number 256,798, filed February 16, 1939.

Various types of explosive circuit interrupters have been proposed and some have had an advantage over the fusible wire type in that the operating characteristics of the explosive type did not vary when subjected to overload conditions less severe than those under which the link was to blow. The explosive circuit interrupters described in the patent to John P. Medlin, No. 1,990,298, have the further advantage that they may be given different time-response characteristics by appropriate selection of the material, and therefore of the mass, of the ignition element. This choice of the mass of the ignition element was possible, and without loss of the desirable characteristic of mechanical and electrical stability under all conditions short of actual failure, as the Medlin circuit breaker was designed for outdoor use and the explosive charge was of such magnitude as to rupture the ignition elements or wires of the largest mass. This choice of the time constant has not been possible in circuit interrupter links with small powder charges, such as described in Patent No. 2,088,152, George L. Carlisle, that are interchangeable with the fuse wire links of the present drop-out circuit breakers. The conflicting design requirements of stable resistance characteristics and low mechanical strength necessitated the use of ignition elements that were of small mass and therefore of low heat storage.

An object of the present invention is to provide an explosive type of circuit breaker which satisfies the design requirements of stable operating characteristics and a small powder charge without placing a limitation upon the time response characteristics of the circuit breaker. An object is to provide a circuit interrupter link having a small powder charge surrounding an ignition element of any desired mass and heat storage characteristics, and a conducting member connected to the ignition element by a joint that opens when the powder is ignited, the joint being designed to afford a stable electrical resistance under all operating conditions and a mechanical resistance to separation which, at least at the operating point of the link, imposes no load or only a nominal load upon the powder charge. An object is to provide an explosive type link including conducting members mechanically connected by a fragile shell that houses a small powder charge, and an ignition element telescoped into the conducting members, the telescoped joint between the ignition element and at least one of the conducting members being mechanically weak to permit rupture of the joint by the powder charge when the current flow through the ignition element raises its temperature to the ignition point of the powder. An object is to provide an explosive type circuit interrupter link having a small powder charge within a fragile shell, a thermal element of any desired mass and corresponding time constant within the shell and secured to one end thereof, and a conductive member secured to the other end of the shell and soldered to the ignition element by a low melting solder that fuses before the thermal element is heated to the ignition temperature of the powder charge. A further object is to provide circuit interrupter links of the explosive type in which the ignition element is mechanically secured to conducting members by telescoped joints that are circumferentially crimped to insure stable electrical resistance characteristics, the mechanical strength of the crimped joints being such that one of the joints will slip when the powder is ignited or, alternatively, the ignition element may be ruptured in the links of low current carrying capacity. A further object is to provide an explosive circuit interrupter link including a fragile shell housing a powder charge, conductive members connected within the shell by a low melting point solder, and a spring for separating the conductive members upon a predetermined overload for a predetermined period, thereby to draw an arc between the conductive members to ignite the powder charge.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawing in which:

Figs. 1, 2 and 3 are fragmentary side elevations, with parts in section, of different embodiments of the invention;

Fig. 4 is a fragmentary perspective view of the crimped joint of the Fig. 3 circuit interrupter link; and

Fig. 5 is a curve sheet showing typical time-current characteristic curves for the Fig. 1 construction and for prior explosive type links.

The explosive cartridge of prior circuit interrupters has been a fragile tube or case housing a small powder charge and an ignition element, the ignition element being the deeply notched intermediate section of a metal strip that extended through the tube to provide conductive members or terminals for connecting the cartridge between the button cap and the flexible lead of the fuse link. The fragile tube was secured to and supported on the metal strip by plugs of cement that closed the ends of the tube to retain the powder charge.

In accordance with this invention, the ignition element is not integral with the conductive members that carry the powder case, but is mechanically connected to the conducting members by joints of low electrical resistance, one of the joints being mechanically weak to offer little or no resistance to rupture upon the ignition of the powder charge. It will be apparent that the particular design of the joints is not important in the case of links of low current-carrying capacity as the mechanical strength of the ignition elements, even when of relatively large mass to obtain a long response characteristic, will be less than the strength of a crimped joint of low electrical resistance. It is preferable, however, to employ the same mechanical design for links of all current ratings as this simplifies the manufacturing processes.

In the drawing, the reference numeral 1 identifies the tubular stem that has a flanged end 2 for engagement with the upper conductive member of the explusion tube assembly in which the link is to be used. The upper end of the stem is filled with soft metal 3 in which the current rating of the link may be stamped, and a removable cap washer 4 is slidable upon the upper enlarged diameter end of the stem to adapt the link for use with expulsion tubes in which the bore of the link seat is of larger diameter than the flanged head 2. An ignition or heater element in the form of a wire or rod 5 extends into the lower end of the stem 1 and is rigidly secured therein by swaging the stem upon the rod. The element 5 may be of a nickel-silver alloy, copper, or any of a number of relatively high resistance alloys that are sold under the trade names "Nichrome," "Everdur," "Midohm," "Hytenco" and "Advance." The particular material to be used in any case will depend upon the desired time-response characteristics and, in general, materials of comparatively high specific resistance will be used to delay the blowing of the link under given overload conditions as the mass of the ignition element increases with the specific resistance of the material employed to obtain a particular absolute resistance.

The circuit interrupter link of Fig. 1 is designed to carry a relatively high current and the ignition element 5 is therefore of substantial size. The lower end of the rod 5 extends loosely into the bore of a tubular conductive member 6 and mercury or a soft solder 7, such as Woods metal, is run into the telescoped joint to afford an electrical connection of low resistance. A flexible cable 8 extends into the other end of the tubular member 6 and the tube is crimped upon the cable to effect a rigid connection of these parts. This deformation of the tube also anchors a flanged collar 9 to the tube.

A thin-walled shell 10 of a fragile insulating material such as glass, fiber or a synthetic resin is telescoped over the lower end of the stem 1 and the collar 9 to retain a small explosive charge 11, for example black powder, in contact with the thermal element 5. The shell 10 is anchored to the stem 1 and to the tube 6 by cement 12, the shell 10 preferably having apertures into which the cement extends to form interlocking lugs 13. The shell has a snug fit on the stem 1 but the swaging of the stem 1 upon the rod 5 provides a space for the cement between the swaged section of the stem and the inner wall of the shell. The shell 10 relieves the soft soldered joint from the stress imposed on the link when it is used, as is now customary, to retain the knockout assembly in operating position so long as the link is intact.

The method of operation of the described link is as follows. The mercury or soft solder 7 fills the space between the rod 5 and the tubular member 6 by capillary attraction and thus provides a low resistance electrical connection at this junction. The soft solder melts before the temperature of the thermal element 5 rises to the ignition point of the powder charge, thereby permitting the thermal element 5 to slide freely from the tubular member 6 and thus restricting the work imposed upon the powder charge to that of shattering the shell 10. In the event that the overload is removed after the melting of the solder 7, the thermal element 5 cools down and the solder again solidifies. The time-current characteristic of the link remains constant throughout the useful life of the link as repeated meltings of the solder under overload conditions short of failure do not alter the electrical or mechanical characteristics of the link.

Different time-current characteristics may be obtained by a selection of the composition and the mass of the thermal element 5. Relatively massive constructions of considerable thermal storage capacity are made possible by the mercury joint or soldered junction which provides good electrical conductivity with substantially no mechanical resistance to separation. It is to be noted that, in view of the relatively large diameter of the element 5, the mechanical strength of a swaged joint between the parts 5 and 6, similar to the swaged joint between parts 1 and 5, would impose a heavy load upon the explosive charge and reliable operation could be had only through the use of heavy powder charges.

The construction shown in Fig. 2 includes a thermal element 5' of such resistance material and dimensions as to melt the solder 7' upon the predetermined overload conditions at which the circuit is to be opened. The tubular member 6' has a free sliding fit in the sleeve 9' that closes the lower end of the shell 10, and carries a collar or seat 14 for one end of the compression spring 15, the other end of the spring bearing against the sleeve 9'. The remaining elements of this construction may be identical with those shown in Fig. 1 and are identified by the corresponding reference numerals.

The thermal element 5' of this link is not heated to the ignition temperature of the powder charge by an overload current but to some lower temperature at which the solder melts. Spring 15 expands upon the failure of the soldered connection and separates the tube 6' from the rod 5', thus drawing an arc which ignites the powder charge. The method of operation thus differs from that of the Fig. 1 type in which the soft solder may melt and solidify one or more times before failure of the link, but the time-current characteristics of both types are stable since the solder 7' may be heated repeatedly to temper-

atures short of its melting point without substantially affecting the mechanical strength of the joint or the ultimate melting point of the solder.

The spring 15 is not necessary when the links are to be used in knockout circuit breakers that apply a relatively heavy stress to the link. The spring 15 is preferably included, however, in all links of this type to insure a rapid withdrawal of the tubular member 6' upon a melting of the soft solder. The time-current characteristic may be controlled by the electrical and thermal properties of the element 6' and/or by the melting point of the solder 7'.

It is not essential that mercury or solder be used to insure a low and stable electrical resistance between the ignition element and the lower conducting member of the link when only relatively low currents are to be carried. The construction of such links, as illustrated in Figs. 3 and 4, differs from that of Fig. 1 only as to the lower telescoped joint, and those parts that are or may be identical with the Fig. 1 link are identified by corresponding reference numerals but will not be described in detail. The ignition element 5'' for rated values of up to about 10 amperes is a relatively fine wire, even in the case of high resistance alloys that afford high heat storage, that is mechanically swaged to the end of the stem 1, and is telescoped into the tubular end of the conducting member 6. The tubular end is circumferentially crimped upon the wire 5'' to insure a good electrical connection between the parts but, in view of the small diameter of the wire 5'', the mechanical strength of the joint is relatively low. The frictional resistance of the joint may be such that a pull of the order of seven pounds will effect a slipping of the contacting surfaces. Forces of this order can be developed by the small powder charge and therefore it is not necessary to employ a loose telescoped joint with mercury or solder for increasing the conductivity.

In the case of links that carry up to about 5 or 7 amperes, the dimensions of the ignition element are such that the ignition element may part without slipping the telescoped joint.

The advantages of the invention will be apparent from a consideration of the curves of Fig. 5.

The solid line curves A, B and C are the time-responsive characteristics of 1 ampere, 10 ampere and 100 ampere links, respectively, that embody this invention. The dotted line curves A', B' and C' are the corresponding characteristics for prior links of the same rating in which the thermal element was mechanically weak to permit fracture by a small explosive charge. The increased mass of the thermal rod 5 of the new design results in a relatively slow heating by overload currents and service is maintained over a range of transient overloads that would blow the prior types of explosive circuit interrupter links. For example, the prior 1 ampere link opened the circuit in 0.1 second when the current rose to about 3.4 amperes, while the Fig. 1 link carries over twice that current for 0.1 second and can carry 3.4 amperes for approximately one second before opening the circuit.

The curves A, B and C are typical of the results that may be obtained but the invention is not restricted to a particular time-response characteristic. A reduction in the mass of the thermal element 5 will result in a quicker response under a given overload and an increase in the mass will provide a slower response.

The described constructions are convenient, efficient and economical but changes may be made in the electrical or physical design of the parts without departing from the spirit of the invention as set forth in the following claims.

We claim:

1. A circuit interrupter link which comprises a fragile shell, a powder charge within the shell, conductive members extending into the shell from the opposite ends thereof, means mechanically and electrically connecting said members to each other, said means comprising an electric resistance element connected to at least one of said conductive members by a telescope joint, the coacting elements of said telescope joint being secured together by crimping to provide a joint which will part when the fuse blows, and means associated with said conductive members respectively for connecting the link into a circuit.

2. A circuit interrupter link which comprises a fragile shell, a powder charge within the shell, conductive members extending into the shell from the opposite ends thereof, means mechanically and electrically connecting said members to each other, said means comprising an electric resistance element connected to at least one of said conductive members by a telescope joint, the coacting elements of said telescope joint being electrically and mechanically connected by a solder that melts below the ignition temperature of the powder, and means associated with said conductive members respectively for connecting the link into a circuit, whereby the only load imposed on the powder charge is that of shattering the fragile shell.

3. A circuit interrupter link comprising a fragile shell, a powder charge within the shell, conductive members extending into said shell from the opposite ends thereof, means mechanically and electrically connecting said members to each other, said means comprising solder that melts below the ignition temperature of the powder, a headed stem secured to one member for supporting the link in an expulsion tube, and a flexible conductor secured to the other member, whereby the only load imposed on the powder charge is that of shattering the fragile shell.

4. A circuit interrupter link comprising a fragile shell housing a powder charge, conductive members secured to said shell and within and extending axially thereof, one member being telescoped into the other, solder of a melting point lower than the ignition temperature of the powder connecting the telescoped ends of said members, and means associated with the respective members for connecting the link into a circuit.

5. A circuit interrupter link comprising a headed stem, a conductive member secured to and in axial alinement with said stem, a second conductive member having a tubular end telescoped over the end of the first member, solder securing said members to each other, a fragile shell secured to the stem and enclosing the telescoped ends of said members, a powder charge within said shell, and a flexible cable secured to the outer end of said second member.

6. A circuit interrupter link as claimed in claim 5, wherein the mass of the first conductive member is such that it is heated to the ignition temperature of the powder upon predetermined overload conditions, and the second member is secured to said shell.

7. A circuit interrupter link as claimed in claim 5, wherein said second member is supported for sliding motion with respect to said shell and the first conductive member, and the mass of the

first conductive member is such that it is heated to the melting point of the solder on predetermined overload conditions.

8. A circuit interrupter link as claimed in claim 5, wherein said second member is supported for sliding motion with respect to said shell and the first conductive member, and the mass of the first conductive member is such that it is heated to the melting point of the solder on predetermined overload conditions, in combination with spring means carried by said second member for displacing the same from the first member upon a melting of the solder.

9. A circuit interrupter link comprising, in series, a headed stem having a counterbored lower end, a rod telescoped into and secured to said stem, a conductive member having a tubular end telescoped over the other end of the rod, solder securing said member to said rod, and a flexible cable secured to said member, in combination with a fragile shell extending over the junction of said rod and member, said shell being secured respectively to said rod and member, and a powder charge within said shell, said solder having a melting point lower than the ignition temperature of the powder charge.

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