Sept. 1, 1942. E. A. WILLIAMS, JR 2,294,767

ELECTRIC PROTECTIVE DEVICE

Filed Aug. 2, 1940

Fig. 1.

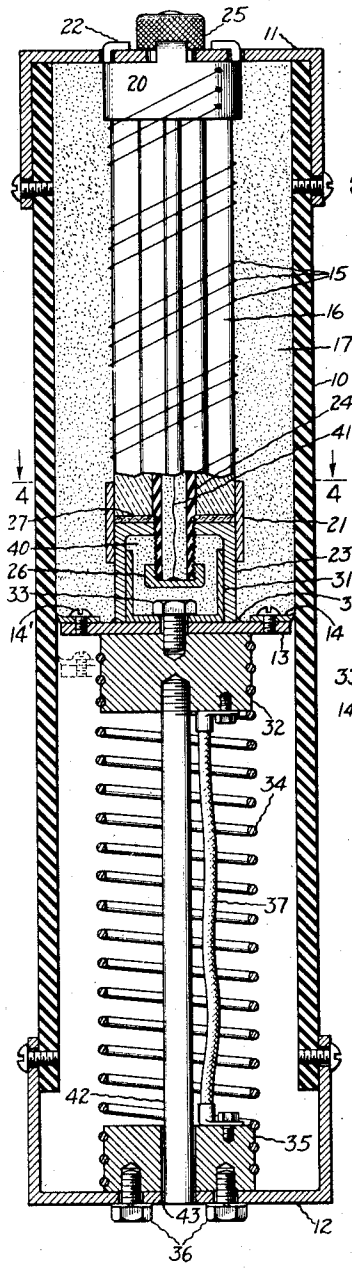


Fig. 2.

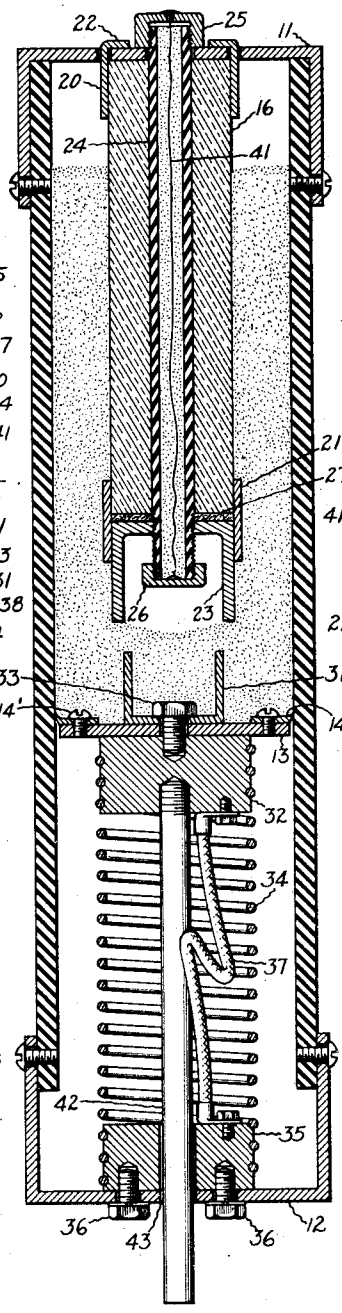


Fig. 3.

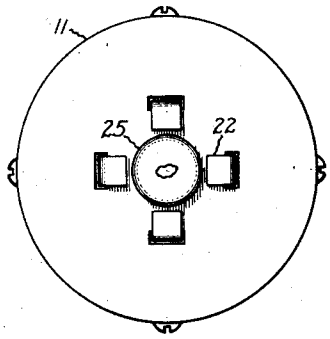
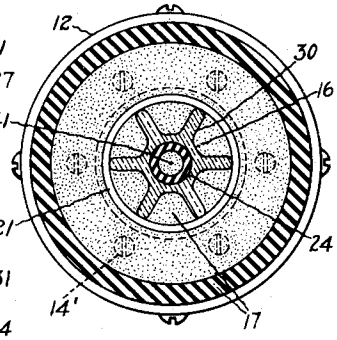


Fig. 4.



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UNITED STATES PATENT OFFICE

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ELECTRIC PROTECTIVE DEVICE

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Application August 2, 1940, Serial No. 349,845

14 Claims. (Cl. 200—120)

The present invention relates to electric protective devices, with reference more particularly to fused circuit interrupting devices.

The invention has for one of its objects the provision of improvements in fuses of the kind sometimes referred to as current limiting fuses because of their ability to limit a short-circuit current to an initial peak magnitude well below the peak magnitude of prospective or available current which a circuit, in which such fuse is connected, otherwise is capable of developing. Fuses of this character normally employ a current interrupting element comprised of one or more long, thin fusible conductors embedded in an inert, granular, arc-quenching material, and which conductors are designed to fuse and dissipate throughout substantially the whole of their length under short-circuit or other severe overcurrent conditions. Such fusion and dissipation of the conductors, followed by dispersion of the metallic vapors into the surrounding granular material and rapid transfer of heat from the arc to the granular material, has the effect of inserting a high resistance into the current path so as to produce the desired current limiting action and interruption of the current in a very short period of time.

It has been found that some forms of current limiting fuses, while being capable of highly satisfactory interruption of large magnitude excess currents in the manner above outlined, have difficulty in completely clearing excess currents, such as low overload currents, which exceed the minimum melting current by only a small amount. This is due to the fact that such low currents may produce only partial fusion and volatilization of the long fusible conductor, or conductors, so that current conduction may continue due to leakage across a relatively short gap. The present invention has for one of its more specific objects the provision of a current limiting fuse having means for inserting an insulating break in series with the interrupting element upon rupture of the fusible section thereof, so as to insure complete and satisfactory current interruption through a wide range, from slight overload currents to severe short-circuit currents.

Another object of the invention is the provision, in an electric protective device including a current interrupting element having a fusible section, of improved mechanism for mechanically inserting an insulating break in series with the interrupting element upon rupture of the fusible section thereof. In accordance with one of the more detailed aspects of the invention, insertion of the insulating break is effected as the result of operation of gas pressure producing means, which means is operative responsively to rupture of the fusible section but independently of any pressure generation resulting directly from arcing between the ruptured ends of the fusible section itself.

A further object of the invention is the provision, in a fused electric protective device, of mechanism operative responsively to rupture of the fusible element of the device and capable of being employed either for giving indication of fuse operation or for effecting operation of other devices or mechanisms.

Other objects and the details of that which I consider to be novel and my present invention will be understood from the following description and the appended claims, taken in conjunction with the accompanying drawing wherein

Fig. 1 shows, in longitudinal section, an exemplary form of fuse device embodying the invention, with the parts of the device in their normal positions;

Fig. 2 shows the positions of certain of the parts of the device following partial operation thereof;

Fig. 3 is a plan view of the upper end of the device of Fig. 1, and

Fig. 4 is a cross-section along the line 4—4 of Fig. 1.

The illustrated fuse has a tubular enclosing casing 10 which is constructed of fibrous insulating material, but which may be constructed of glass, porcelain, or other suitable material having the desired strength and electric insulating properties. The upper and lower ends of the casing are closed respectively by metallic terminal caps 11 and 12 which are adapted for connection of the fuse device in an electric circuit. The interior of the casing is divided into an upper and a lower compartment by partition means comprising a relatively stiff plate 13 and a relatively flexible sealing ring 14. Ring 14 extends around the periphery of plate 13 and is secured on the upper side of the plate by means of screws 14'. In the upper compartment of the casing are disposed the elements of a current limiting fuse: a current interrupting element comprising a plurality of long fusible conductors 15, a supporting core 16 extending longitudinally in the casing and upon which conductors 15 are spirally wound, and a body of arc-quenching medium 17 which surrounds core 16 and embeds conductors 15.

In the illustrated embodiment, three fusible conductors 15 are employed and these conductors are in the form of fine silver wires. However, less or more than three fusible conductors may be employed, depending upon the current rating of the fuse, and the conductors may be comprised of any suitable metal other than silver, while the conductors also may be in the form of thin ribbons or foils. Conductors 15 are connected in parallel between metallic terminal collars 20 and

21 disposed respectively at the upper and lower ends of core 16. Collar 20 surrounds the upper end of the core and is attached to the end of terminal cap 11 by means of bent-over tabs 22. Collar 21 tightly surrounds the lower end of the core and a portion of a terminal contact 23 mounted on the lower end of the core.

Core 16 is constructed of quartz, porcelain, or other suitable material having good refractory and electrical insulating properties. An insulating tube 24, filled with arc-quenching medium 17, extends through a central longitudinal bore in core 16 and has metallic caps 25 and 26 screw-threaded respectively on the upper and lower ends thereof. Terminal contact 23 also is screw-threaded on the lower end of tube 24, and the upper end of the tube extends through a central opening in terminal cap 11. The tube, together with cap 25 and contact 23, serves to clamp the core to cap 11 and maintain the core in proper position in the casing. A washer 27 of soft fibrous material is interposed between the lower end of the core and contact 23 in order to relieve the core of clamping strain. As will be seen best from Fig. 4, the core is of generally star-shaped cross-section in that it has a plurality of longitudinally extending fins or ribs 30 which serve to maintain conductors 15 in spaced relation to the central body portion of the core so that the maximum length of the conductors is completely surrounded and embedded by the quenching medium 17. This quenching medium is of granular form, and is comprised of sand, pulverized quartz, or other material which is highly insulating and which is substantially inert, or non-gas-producing, at the temperatures likely to be encountered in fuse operation.

The previously mentioned partition means, comprising plate 13 and ring 14, forms part of a structure arranged for movement longitudinally in casing 10, and which structure also includes a metallic contact 31 and a metallic connection block 32. Contact 31 is secured on the upper side of plate 13 by means of a screw 33 which serves also to secure block 32 on the lower side of plate 13. A coil spring 34, disposed in the lower compartment of casing 10, biases the movable structure for movement toward the lower end of the casing. This spring is connected between block 32 and a second connection block 35, which latter is secured to lower terminal cap 12 by means of screws 36. A flexible conductor 37, connected between blocks 32 and 35, is provided for electrically bypassing the spring.

Normally the movable structure is restrained in the position shown in Fig. 1, wherein contact 31 engages contact 23 so as to effect electric connection of the lower fuse terminal means, comprising parts 21 and 23, with the lower terminal cap 12. Under these circumstances, the circuit through the fuse device extends from upper terminal cap 11 through collar 20, conductors 15, collar 21, contacts 23 and 31, plate 13, connection block 32, flexible conductor 37, and connection block 35 to the lower terminal cap 12.

Since conductors 15 are spirally wound on their supporting core, it is impractical to employ these conductors themselves for restraining the movable structure, including contact 31, in the position indicated in Fig. 1. Hence, small bodies of solder, indicated at 38, are employed for releasably joining plate 13 to contact 23. As will be seen from the drawing, contacts 23 and 31 are cup-shaped and interfit, when the movable structure is restrained as above described, so as to provide a relatively tight enclosure. Cap 26 is arranged in spaced relation to the head of screw 33 so as to form a gap in this enclosure. A suitable material 40, capable of producing gas upon being subjected to the heat of an arc, is disposed within the enclosure so as to be exposed to arcing between cap 26 and screw 33. Normally, screw 33 is electrically connected with the lower ends of conductors 15 through contacts 31 and 23 and terminal collar 21. Cap 26 is electrically connected with cap 25 and the upper fuse terminal collar 20, by means of a wire 41 which extends through tube 24 and which preferably is constructed of a high resistance material such as, for example, the material known as Nichrome. Thus the gap, formed between cap 26 and screw 33, is connected in shunt with the conductors of the main current interrupting element.

Upon subjection of the fuse device to excess current of large magnitude, such as under severe short-circuit conditions, conductors 15 fuse and volatilize throughout substantially the whole of their length and arcing is initiated along the paths formerly occupied by these conductors. As a result of the dispersal of the metallic vapors through the granular material 17 and the rapid transfer of heat from the arc paths to this material, a pronounced current limiting action is produced in the manner previously indicated. At the same time, voltage is impressed across the gap between cap 26 and screw 33 and this gap breaks down. With breakdown of the gap and arcing thereacross, current flows in conductor 41 which due to its higher resistance, produces some further current limitation so as to aid in the final current interruption. Upon subjection of material 40 to arcing across the gap, gas is produced in the enclosure formed by contacts 23 and 31 and the resultant pressure ruptures the restraining solder joint 38. Thereupon contact 31 is forced out of contact 23 and spring 34 collapses so as to produce a rapid separation of the contacts. As the contacts separate, an arc is drawn therebetween but this arc is quickly extinguished by flow of the granular material 17 between the contacts, as indicated in Fig. 2. Thus the high resistance conductor 41 and the insulating break between contacts 23 and 31 materially aid in the final interruption of large magnitude excess currents.

Upon subjection of the fuse device to excess current of relatively small magnitude, such as a low overload current, conductors 15 may not fuse and volatilize throughout the whole of their length, and current leakage may exist across short gaps between the ends of the ruptured conductors in spite of the action of the quenching material 17. However, in any case, sufficient voltage is established across the gap between cap 26 and screw 33 to cause arcing across this gap. Then, in the manner previously described, gas pressure is produced in the enclosure formed by contacts 23 and 31, solder joint 38 is ruptured, and spring 34 effects separation of the contacts so as to provide an insulating break in series with the current interrupting element and thereby completely interrupt the current flow.

The functioning of the various elements of the described fuse device and the relative importance of the elements with respect to the final current interruption, may vary for different current values within the interrupting capacity of the fuse device. However, in each case an insulating break is produced in series with the interrupting element, so that complete and final cir-

cuit interruption is insured for a wide range of excess currents, from low overloads to severe short circuits.

It is desirable to provide some means for giving indication of fuse operation. In the illustrated embodiment such means is provided in the form of a rod 42 which is screw-threaded at one end into connection block 32. The other end of this rod is arranged to extend through an opening 43 in connection block 35 and the end of terminal cap 12. Upon operation of the fuse device in the manner previously described, and collapse of spring 34, the rod is caused to project out of the end of the casing to provide the desired indication. This rod also may be employed as a plunger for effecting operation of other devices or mechanisms in response to operation of the fuse device.

The present invention is not limited in all its aspects to particular details of the illustrated embodiment, and it is contemplated that modifications and other embodiments of the invention may suggest themselves to those skilled in the art. It is to be understood therefore that I desire to cover by the appended claims such other modifications and embodiments as do not depart from the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An electric protective device comprising a casing, inert granular arc-quenching material therein, a current interrupting element having a long fusible section embedded in said material, spaced terminals for connecting said element in an electric circuit, one of which terminals is electrically connected with one end of said element, the other end of said element having terminal means relatively fixedly supported in said casing, means for electrically connecting said terminal means with the other of said casing terminals including a conductive part arranged for movement in said casing and normally restrained in a position conductively connected with said terminal means, and means operative dependently upon rupture of said fusible section for effecting release of said part and displacement of the part relative to said terminal means in a manner to provide an insulating break in series with said interrupting element.

2. In an electric protective device including a casing having spaced terminals, an insulating support disposed in said casing, a current interrupting element spirally wound on said support and including a long fusible section, and an inert granular arc-quenching material surrounding said support and embedding said fusible section; means for electrically connecting said interrupting element between said terminals including a movable conductive part normally restrained in a position conductively connected with one end of said element, and means including a spring operative dependently upon rupture of said fusible section for effecting release of said part and displacement of the part from its said normal position in a manner to produce an insulating break in series with said interrupting element.

3. In an electric protective device, a casing having inert granular arc-quenching material therein, a current interrupting element having a long fusible section embedded in said material, spaced terminals for connecting said element in an electric circuit, means for electrically connecting said element between said terminals including a movable conductive part normally restrained in a position conductively connected with one end of said element, and means operative dependently upon rupture of said fusible section for effecting displacement of said conductive part from its said normal position in a manner to provide an insulating break in series with said interrupting element, a portion of said granular material being arranged to flow into such break upon displacement of said part as aforesaid.

4. In an electric protective device, a casing, two compartments therein separated by partition means, at least a portion of said partition means comprising part of a structure arranged for movement in said casing, granular arc-quenching material in one of said compartments, a current interrupting element in said one compartment and including a fusible section embedded in said material, spaced terminals for connecting said element in an electric circuit, means for electrically connecting said element between said terminals including a conductive part of said movable structure, said structure normally occupying a position wherein said conductive part is conductively connected with one end of said interrupting element, and means operative dependently upon rupture of said fusible section for effecting displacement of said structure in a manner to disconnect said conductive part from said one of said elements and thereby provide an insulating break in series with said element, a portion of said granular material being arranged to flow into said break upon displacement of said structure as aforesaid.

5. An electric protective device comprising a tubular casing having spaced terminals, partition means separating one portion of said casing from another portion thereof, at least part of said partition means comprising part of a structure which is movable longitudinally in said casing, an insulating support and a body of granular arc-quenching material in said one portion of the casing, a current interrupting element wound on said support and having a fusible section embedded in said material, said element normally being electrically connected between said terminals, a contact carried by said movable structure, said structure normally being restrained in a position wherein said contact is conductively connected in series between one of said terminals and one end of said interrupting element, a spring in said other portion of said casing and connected with said movable structure, and means including said spring operative dependently upon rupture of said fusible section for effecting movement of said structure in a manner to disconnect said contact from said one end of said element and thereby insert an insulating break in series with said element, a portion of said granular material being arranged to flow into such break, upon movement of said structure as aforesaid.

6. In an electric protective device, a casing, a current interrupting element supported therein and having a fusible section, inert granular arc-quenching material embedding said fusible section, spaced terminals for connecting said element in an electric circuit, means for connecting said element between said terminals including a conductive part normally occupying a position electrically connected in series with said element, which said part is displaceable from its normal position to provide an insulating break in series with said element, means operative dependently upon rupture of said fusible section for developing gas under pressure, and means including said

gas pressure producing means for effecting displacement of said part from its said normal position.

7. In an electric protective device, a current interrupting element having a fusible section, spaced terminals for connecting said element in an electric circuit, means for connecting said element between said terminals including a conductive part normally occupying a postion electrically connected in series with said element, which said part is displaceable from its said normal position to provide an insulating break in series with said element, means providing a gap in shunt with said element and arranged to arc over upon rupture of said fusible section, means operative responsively to arcing across said gap for developing gas under pressure, and means including said gas pressure producing means for effecting displacement of said conductive part from its said normal position.

8. In an electric protective device, a current interrupting element having a fusible section, means for connecting said element in an electric circuit including a conductive part normally restrained in a position conductively connected with said element, means providing a gap in shunt with said element and arranged to arc over upon rupture of said fusible section, means operative responsively to arcing across said gap for producing gas under pressure, said conductive part being releasable from its said normal position by such pressure, and a spring operative upon release of said part for effecting movement of the part in a manner to provide an insulating break in series with said interrupting element.

9. In an electric protective device, a current interrupting element having a fusible section, spaced terminals for connecting said element in an electric circuit, means providing a relatively tight enclosure, a movable structure including a conductive part, means releasably restraining said structure in a position wherein said part is connected in series with said interrupting element, said restraining means being operative to release said structure in response to pressure in said enclosure, means providing a gap in shunt with said interrupting element and arranged to arc over in said enclosure upon rupture of said fusible section, a material in said enclosure capable of developing gas upon subjection thereof to arcing across said gap, a spring for effecting movement of said structure, and means including said spring operative upon release of said structure for effecting movement of said structure from its said position in a manner to disconnect said conductive part from said interrupting element and thereby insert an insulating break in series with said element.

10. An electric protective device comprising an enclosing casing having spaced terminals, an insulating support disposed in said casing and having a current interrupting element wound thereon, said element having a fusible section, inert granular arc-quenching material embedding said fusible section, means electrically connecting said interrupting element between said terminals, said means including a first conductive member on said support and a second conductive member movable relative to said first member, frangible means restraining said members in conductive relationship, said members when so restrained having means cooperating to form a relatively tight enclosure and said frangible means being rupturable by development of pressure in said enclosure, means in shunt with said interrupting element and operative to produce arcing in said enclosure upon rupture of said fusible section, material in said enclosure operative to produce gas in response to such arcing, and a spring for effecting rapid separation of said second member from said first member upon rupture of said frangible restraining means.

11. In an electric protective device, a casing, a body of inert granular arc-quenching material in said casing, a current interrupting element having a fusible section comprised of one or more long thin fusible conductors, and which said fusible section is embedded in said granular material, spaced terminals for connecting said interrupting element in an electric circuit, a pair of conductive elements arranged in spaced relationship both electrically and mechanically so as to provide a gap, and means for connecting said gap electrically in shunt with said interrupting element including a conductor comprised of high resistance material and designed to effect a substantial reduction in current flow upon breakdown of said gap due to rupture of said fusible section.

12. In an electric protective device, an enclosing casing, a current interrupting element disposed therein and including a fusible section, spaced terminals for connecting said element in an electric circuit means providing a gap connected in shunt with said element and arranged to arc over upon rupture of said fusible section, means operative responsively to arcing across said gap for producing gas under pressure, a plunger-like member normally disposed in a retracted position, and means including said gas pressure producing means for effecting movement of said member to a position wherein the member projects substantially from said casing.

13. In an electric protective device, a current interrupting element having a fusible section, an enclosing casing therefor, spaced terminal means for connecting said element in an electric circuit, means providing a relatively tight enclosure in said casing, means providing a gap connected in shunt with said element and arranged to arc over upon rupture of said fusible section, gas producing material operative responsively to such arcing for developing pressure in said enclosure, a member spring biased for movement to a position wherein the member projects substantially from said casing, and means normally restraining said member in a retracted position, said restraining means being releasable responsively to development of pressure in said enclosure.

14. In an electric protective device, an enclosing casing, a current interrupting element disposed therein and having a fusible section, means for connecting said element in an electric circuit, said means including a conductive part arranged for movement in said casing and normally disposed in conductive relation with one end of said element, means operative dependently upon rupture of said fusible section for effecting displacement of said part in a manner to provide an insulating break in series with said element, and a member supported for movement with said part and arranged to extend out of said casing, said member normally occupying a retracted position and being moved to a position projecting substantially from said casing upon displacement of said conductive part as aforesaid.

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