May 14, 1946. A. HAEFELFINGER 2,400,408

ELECTRICAL CIRCUIT BREAKING FUSE OF THE CONTROLLED OPERATION TYPE

Filed March 23, 1943

FIG. 1

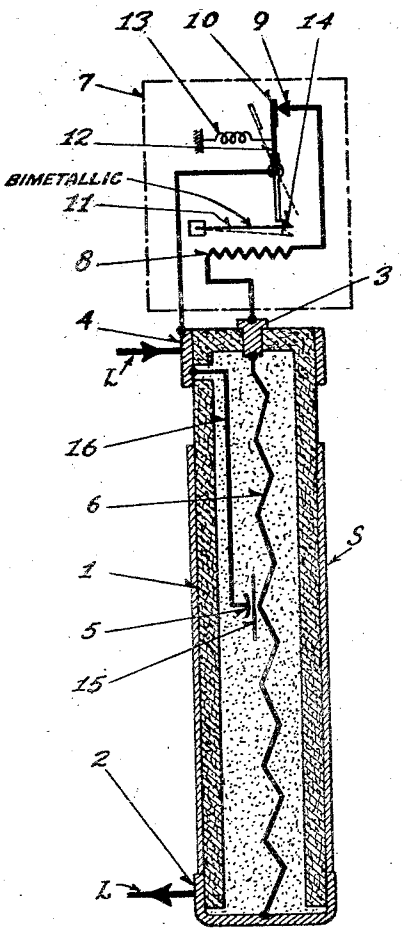


FIG. 2

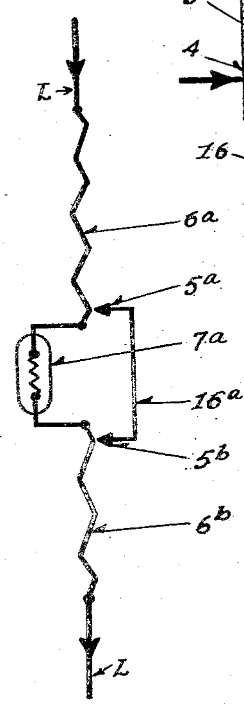
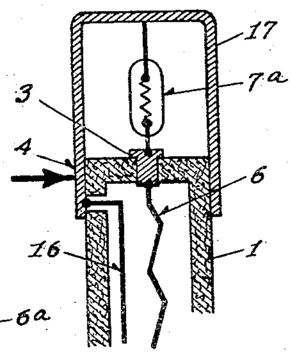


FIG. 3



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ELECTRICAL CIRCUIT BREAKING FUSE OF THE CONTROLLED OPERATION TYPE

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3 Claims. (Cl. 200—118)

Wire or strip fuses, known as fusible fuses, are extensively used as circuit breaking means for protecting electrical appliances and devices against overload or lightning. The most up-to-date fusible fuse structures enable a high degree of protection to be obtained owing to simplicity of their operation and reliability in melting under predetermined load. However, in some cases, wire fuses cannot be used except with difficulty, particularly when they must be used to protect a high tension electrical appliance having a very low current consumption such, for example, as a voltage transformer. In fact, as the current consumption of such appliances is very small, the intensity of the service current which permanently passes through them represents a small fraction of one ampere. Consequently, in order to efficaciously protect them against overload, the fuse or cut out should have an extremely thin fusible wire, but, such wires are very delicate and liable to become damaged, for example, during manufacture when the wire is being set in position, or after manufacture, by manipulation in handling or installation or by the effect of the intensive electrostatic field applied to the wire surface. It is well known that the intensity of this field increases as a direct function of the service voltage and as a reverse function of the wire diameter. For practical purposes, protection of voltage transformers against overloads by means of high voltage wire fuses had to be abandoned and such protection limited to short circuit phenomena by means of a high voltage fuse comprising a wire so selected as to melt off under a current of approximately one ampere, that is to say a high multiple of the service current intensity used in such appliances.

An object of the present invention is to provide a new or improved wire fuse, or cut out, obviating the aforesaid disadvantages by providing a circuit breaking fuse of the controlled operation type by which a much smaller current intensity causes the fusible wire to melt, than that which would be necessary to melt it under the influence of the Joule effect.

Another object of the invention is to provide an electrical circuit-breaking fuse of the controlled operation type comprising a primary fusible element housed in an envelope filled with means for extinguishing the electric arc produced after melting, and an auxiliary electrical conducting element extending at least partly within the means for extinguishing of the arc. This conducting element is part of an auxiliary circuit intended to shunt an electrical circuit-breaking element connected in series with the fusible element at the instant said circuit-breaking element is opened, and is positioned so that at least a part of its length is disposed at such a distance from the fusible element that the lowest operating voltage of the auxiliary circuit remains lower than the voltage following the opening of the circuit-breaking element. The opening of said circuit-breaking element results in the energizing of the auxiliary circuit by means of at least one arc between the fusible element and the conducting element, whereby said arc will destroy at least a part of the fusible element and thus initiate the melting of the same.

A further object of the invention is to provide a fuse of the type set forth wherein the auxiliary conducting element is fusible and has its inner end placed close to the primary fusible element and separated from the latter by dielectric means, its other end being connected to a terminal forming part of the envelope of the fuse, this terminal being intended to be electrically connected across the circuit-breaking element to the primary fusible element, the thickness and the electrical characteristics of the dielectric means being chosen in such a manner that the lowest operating voltage of the auxiliary circuit remains lower than the voltage following the opening of the circuit-breaking element.

With these and other objects in view, the invention consists in the novel construction and combination of parts hereinafter described with reference to the accompanying diagrammatic drawing, wherein:

Figure 1 is a sectional view of the entire fuse.

Figure 2 is a fragmentary view showing a modification of the fuse wire.

Figure 3 is a fragmentary sectional view showing a modification of a constructional detail.

In Figure 1 the improved fuse comprises, a casing 1, containing an inert medium such as flint powder having imbedded therein a primary fusible element constituted preferably by a silver wire 6, said wire being electrically connected to a pair of terminals 2 and 3, arranged on the opposite end faces of the casing 1.

A distinguishing feature of the invention resides in the provision of an auxiliary circuit for shunting a circuit breaker 7, said circuit including an electrode 5 situated a short distance from an intermediate portion of the primary fusible element 6, said electrode 5 being electrically connected by a conducting element 16 to a third terminal 4 fixed to the casing wall and constituted by a suitable ring. In order to enable this ring to be properly secured, one of the two cup-shaped end portions 2, which in fuses of this type generally form the terminals for the fusible wire 6, is omitted at the upper end of the casing 1 and replaced by the aforesaid central plug terminal 3.

The fusible wire 6 which extends throughout the length of casing 1 is adapted to be connected in series with the line circuit whose terminals are indicated by L—L, of the electrical appliance (not shown) and which it is desired to protect against overload. The said fuse 6 is also connected with an actuator for controlling its operation, said actuator comprising a circuit breaking element 7. The electrode 5 and the auxiliary conducting element 16 form part of an auxiliary circuit intended to be electrically connected to the feeding circuit beyond the circuit breaker 7, and to the primary fuse wire 6 across this circuit breaker 7. Owing to this arrangement, the auxiliary circuit 4, 16, 5 is connected in parallel to the circuit breaker 7. The latter may be made up of several switch elements connected in series. Alternatively several circuit breakers may be provided and connected in series. All such alternatives are intended to be covered by the expression "electrical circuit breaking element" used in the claims.

In order to facilitate proper understanding of the wire fuse operation, there is shown in Fig. 1 a circuit breaker constituted by a thermal overcurrent-relay. This relay includes a heater or resistor 8 electrically connected at one end to the plug 3 and at its other end to a stationary contact 9. This relay further includes a movable contact 10 connected to the line circuit through the conductive ring 4 and carried by a rockable lever 12 held in contact-closing position against the action of a spring 13 by a latch 14, which, when moved from locking position, releases the lever 12 and moves the contacts 9, 10 off each other. Release of the lever 12 is controlled by a temperature-responsive element 11 such as a bi-metallic blade arranged adjacent the heater 8 and operatively connected to the latch 14.

To protect the wire 6 against the disturbing effect of the intensive electrostatic field applied to its surface (corona effect) the casing is provided with a metallic sheath S covering partly the outer surface of the casing and being electrically connected to one of the terminals 2 or 4.

The operation of the device is as follows:

Under normal functioning conditions, the contacts 9, 10 are in closed position as shown in the drawing. The heater 8 is so built as to be able to withstand, for an unlimited period of time, at least the nominal current intensity supplied to the device to be protected. Assuming the appliance to be a measuring voltage transformer, said nominal intensity will be very small, for example, equal to a few hundredths of one ampere.

Generally, electrical high voltage circuit breaking fuses for protecting high voltage measuring transformers are provided with a wire calibrated to melt under a current having an approximate intensity of one ampere. Owing to practical reasons, such as the corona effect and the over-all length of the fuse, high voltage wire fuses of smaller caliber cannot be successfully manufactured. However, such reasons do not prevail to the same extent in the construction of thermal overcurrent relays because, on one hand, the heater 8 does not melt but is exclusively adapted to heat the temperature-responsive bi-metallic element and, on the other hand, as the voltage between the heater terminals cannot exceed the drop of voltage therein, it is an easy matter to protect the same or the whole relay from corona effects by some suitable metal covering such as the sheath S, subjected to voltage input. Therefore, when making the heater 8, a conductor element can be used which has a larger sectional area than the wire of a fuse which operates on the same current intensity, while opening the relay may be effected as soon as the traversing intensity of the current exceeds, for example, twice the value of the nominal intensity.

Where such an intensity is reached, the heater 8 evolves a thermal energy which is four times larger than its value under normal operative conditions. The temperature-responsive element 11 then operates the latch 14 to release the pivotal lever 12 which is then rocked by the spring 13. The contacts 9, 10 are then moved off each other to cause the voltage resulting from their separation to be larger than the voltage necessary to produce a spark between the fusible wire 6 and the electrode 5. In order to facilitate the priming or energizing of the auxiliary circuit the contacts 9, 10 should be separated very suddenly, while the electrode 5 should be brought as closely as possible to the fusible wire 6 so as to lessen the priming voltage, that is to say, the lowest operating voltage of the auxiliary circuit. To that effect, a very thin insulating sheet or foil 15 may be provided, said foil being clamped between the fusible wire 6 and the electrode 5. This particular arrangement is not, however, limitative and any equivalent dielectric, whether liquid or gaseous, may be provided for the same purpose. When the contacts 9, 10 are separated to the extent of a few millimeters, this is sufficient to produce an arc between the fusible wire 6 and the electrode 5. This arc shunts the relay 7 and as the electrical resistance of the relay circuit is larger than the resistance of the auxiliary circuit, the relay is thereby automatically and entirely protected against destruction. Moreover, this arc destroys the fusible wire 6 over a certain length so as to break the circuit.

In order to prevent the overall length of the fuse casing (one feature determining its breaking capacity) from becoming unduly large, the electrode 5 and the conductor 16 or at least a portion of these may be constituted by a fusible silver wire, having the same cross sectional area as the fusible silver wire 6. Thus the safety factor will remain unimpaired although the circuit breaking element is not built for cutting off the service voltage.

Should a short circuit occur, the melting of the wire 6 is so swiftly accomplished that the circuit breaking element 7 which has a much larger thermal capacity will not be damaged and will remain in closed position. The appliance, and more generally the system are protected by the melting of the fusible wire 6. In any case, as the thermal capacity of the heater 8 is much larger than that of the wire, the heater will never be damaged.

The circuit breaking element may be constituted by a fuse 7*a* as shown in Figures 2 and 3. It will be understood that the space between its terminals must only be sufficient to provide an arc voltage higher than the lowest operating voltage of the auxiliary circuit, that is, higher than the voltage for producing a spark between the wire 6 and the electrode 5. This fuse 7*a* may be of very short length and may be housed and protected within a metal cowl (Figure 3) which is subjected to the overload voltage so as to lessen the electrostatic field applied to the wire surface of the fuse. Under practical conditions, such fuses can be manufactured more satisfactorily, and, may comprise, for example, a glow bulb or tube of usual construction.

In Figure 2, the fusible wire is made up of two lengths 6*a*, 6*b*, interconnected by the circuit breaking element 7*a*. The auxiliary circuit comprises a pair of electrodes 5*a*, 5*b*, electrically connected by an intermediate conductor 16*a* and embedded in the means for extinguishing the melting arc, each of said electrodes being arranged adjacent one of the lengths 6*a*, 6*b* of the fusible wire. Should a dangerous overload occur, the fuse which constitutes the circuit breaking element 7*a* will melt and as the voltage resulting from the melting of this element is higher than that required for energizing the auxiliary circuit, the latter is so to speak primed by two arcs which form between the fusible wire lengths 6*a*, 6*b*, and the electrodes 5*a*, 5*b*. Consequently, the circuit breaking element 7*a* becomes shunted and therefore will be completely protected against destruction of the bulb by the auxiliary circuit. However, each of the arcs which span the gaps between the auxiliary circuit and the two fusible wires melts and destroys a length thereof, thereby causing the fusible wire to be broken.

It will be seen that the only requirement which must be fulfilled by the circuit breaking element, apart from operating or tripping conditions (gage or caliber intensity and eventually imperative lag which can be chosen either as a fixed or variable value in function with the overload) is a sufficient gap or space between its terminals to enable a current to be generated through the auxiliary circuit by initiating the production of at least one arc across the gap between the auxiliary circuit and the fusible wire. The circuit-breaking element may be arranged adjacent the wire fuse or in surmounting relation thereto, as shown in Figure 3. In the latter event, the appliance may be entirely protected by means of the improved wire fuse without requiring any modification of the general structure of the electrical layout of the plant.

In all cases, in order to prevent the circuit-breaking element from being damaged, regardless of the voltage which may appear between its contacts after opening (said voltage being determined by the electrical characteristics of the circuit through which the wire fuse is connected and by the momentary load of said circuit) spark gaps may be provided in parallel with said breaking means so as to keep down the voltage arising from the opening of said element to a predetermined limit. In such case, the priming voltage for the auxiliary circuit, that is, the lowest operating voltage of the auxiliary circuit, should be smaller than the sparking voltage across the opposite faces defining the said gap.

I claim:

1. In an electrical circuit breaking fuse of the controlled operation type, a primary fusible element having its opposite ends respectively connected with an insulated plug and one of the fuse terminals, a circuit breaker in series with the plug and the other fuse terminal, and an auxiliary circuit for shunting the circuit breaker when the latter opens under predetermined electrical overload, said auxiliary circuit comprising a conductor having one end connected with the last-mentioned fuse terminal and having its other end in spaced arc producing relation to the primary fusible element, whereby when the circuit of the circuit breaker is opened the auxiliary circuit delivers the electrical overload to the said electrode thereby to cooperate with the fusible element to produce an arc which ruptures the same.

2. In an electrical circuit breaking fuse of the controlled operation type, an insulating envelope having an end insulating wall and also having an arc extinguishing filler therein, a metal cap at the end of the envelope opposite the insulating end wall and constituting one line terminal, a ring at the end of the envelope having the insulating end wall and constituting the other line terminal, a metal plug in said insulating end wall, a fusible element connecting said plug and cap and embedded in said filler, a circuit breaker in series with the ring and plug, and an auxiliary circuit comprising a conductor embedded in said filler and having one end connected to said ring and provided at its other end with an electrode disposed in spaced arcing proximity to the fusible element, said auxiliary circuit being in parallel with the circuit breaker whereby upon the opening of the circuit breaker due to an overload of predetermined intensity the auxiliary circuit shunts the circuit breaker and transmits the abnormal voltage to the electrode to produce an arc which ruptures the fusible element.

3. In an electrical circuit-breaking fuse of the controlled operation type, an insulating envelope having an end insulating wall and also having an arc extinguishing filler therein, a metal cap at the end of the envelope opposite the insulating end wall and constituting one line terminal, a ring at the end of the envelope having the insulating end wall and constituting the other line terminal, a metal plug in said insulating end wall, a fusible element connecting said plug and cap and embedded in said filler, a thermal relay circuit breaker in series with the ring and plug, and an auxiliary circuit for shunting the relay when it is open, said circuit including a conductor extending into the filler of the envelope and having its terminal in arcing proximity to said fusible element.

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