Oct. 12, 1937. H. H. FAHNOE 2,095,736

CIRCUIT INTERRUPTER

Filed Feb. 21, 1936

Fig. 1.

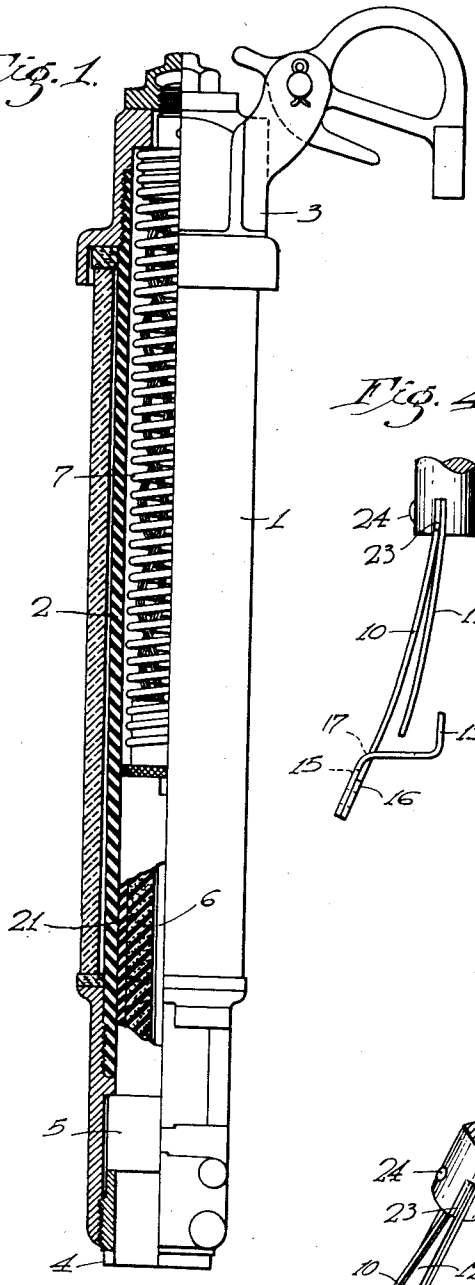
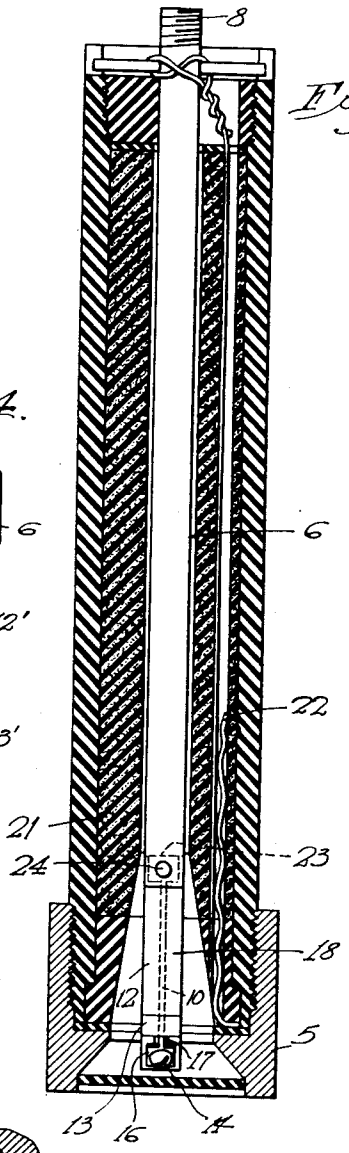


Fig. 4.

Fig. 2.



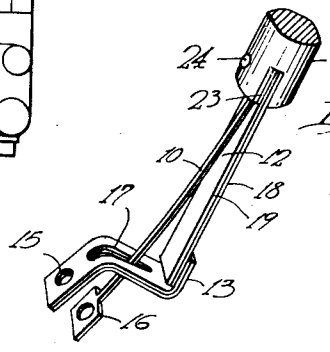


Fig. 3.

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CIRCUIT INTERRUPTER

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22 Claims. (Cl. 200—117)

This invention relates to circuit interrupters, and particularly to fuses of the type having a tube and a fusible element at least a portion of which is expelled from the tube by the action of the arc.

It is an object of this invention to provide an interrupter in which the interruption is certain and prompt and will occur at a current predetermined within narrow limits.

It is a further object of this invention to interrupt the current by the fusion of a wire which requires high temperature to fuse it, but which will be without substantial effect upon the temperature of the fuse tube and will not affect decomposition of a substantial portion of the lining thereof.

It is a further object of this invention to so control the heating of said fusible element that it will remain at a comparatively low temperature until within a very short time before it is fused.

It is a further object of this invention to provide an interrupter of the type in which a spring tends to move a conductor lengthwise within a tube, drawing the arc into the tube, when said conductor is released, the release of said conductor being dependent upon the successive fusion of two parallel connectors.

It is a further object of this invention to provide two connectors for a fuse of the type described, one of which shall have two portions united by a fusible joint and the other shall have a greater mechanical strength than the jointed one.

It is a further object of my invention to provide a connector with a fusible joint which is of greater area at the joint than at other regions. The heat generated by the electric current through the narrow parts of the connector reaches the joint by thermal conduction and is large compared with the heat generated in the joint by the electric current therethrough.

It is a further object of this invention to make the stronger of said two connectors of a wire that will fuse when required to carry the whole of the current, the portion of which carried by the jointed connector, when both connectors were carrying current fuses the joint in said jointed connector.

It is a further object of this invention to provide a fuse element having a fusible joint placed under mechanical stress in response to current flow by means of a member of bimetallic material.

Other objects of the invention and details of the proposed structure will be evident from the following description and the accompanying drawing in which:

Figure 1 is a side elevational view, partly in section and with certain portions broken away, of an expulsion fuse including the features of this invention.

Fig. 2 shows a central longitudinal sectional view of the refill unit of the fuse,

Fig. 3 is a perspective view of the connections between the movable and the stationary terminal elements of the fuse, and

Fig. 4 is an elevational view similar to Fig. 3 showing a modified form of the invention with two of the parts in the separated position which they take as the fuse begins to open.

In Fig. 1, a porcelain tube 1 encloses a fiber tube 2 which encloses the interrupter element and biasing spring. A terminal cap 3 at the upper end and a cylindrical element 4 at the lower end constitute the terminals at which connections are made to the external circuit. A ferrule 5 near the lower end and a rod 6 spring-biased toward the upper end constitutes the terminal conductors between which the connection is to be opened.

The connection from the cylinder 4 to the ferrule 5 and that from the rod 6 to the upper cap 3 are of a familiar sort and are not further described herein. Reference is made to the patent to Rawlins No. 1,976,634 issued October 9, 1934 for a detailed description and illustration of said connections. The spring which biases the rod 6 toward the upper end of the tube is shown in Fig. 1 at 7 and is attached to the rod by a construction illustrated in said patent and including the threaded end 8 of said rod.

The ferrule 5 is connected to the rod 6 by two connections one of which is the wire 10 of "Nichrome" comprising about 78% nickel—20% chromium, and the other of which is composed of two metal straps, namely, a member 12 permanently attached to the rod 6 and a bent member 13. The member 13 and the wire 10 are secured together and to the ferrule 5 by a screw 14 which passes through a hole 15 in the end of the member 13 and a hole in an enlargement 16 on the end of the wire 10. The wire 10 preferably passes through a slot 17 in the member 13 whereby the wire 10 may flex so that the pull of the rod 6, urged by the spring 7, will be nearly in a straight line with the length of the wire. The strips 12 and the wire 10 are fastened in slot 23 in the end of rod 6 by means of solder and a rivet 24.

Preferably the member 12 is of bimetal, the portion 18 having a larger coefficient of expansion than the portion 19. The member 12 may, however, be a leaf spring having no bimetallic construction. The member 13 may also be made of bimetal, but that is not necessary. If it is made of bimetal, the portion next to the member 12 should have the larger coefficient of expansion. The members 12 and 13 are soldered together. For this purpose their overlapping portions are of considerable area, so that the area of the soldered joint is nearly that of a square, one side of which is the width of the widest part of the strip 12.

When soldering the joint between members 12 and 13 the parts shown in Fig. 3 are placed under tension, whereby the tension exerted by the spring 7 when the whole fuse is assembled will produce no strain in the joint. The tension both when the soldering is being done and when the fuse is assembled is supported by the strain wire 10.

If desired, the major member 12 may be narrow over the major part of its length and only the portion at the soldered joint be large to afford the large area for the joint. The width of the member 12 is determined by the resistance it is intended to have. When the member 12 is of bimetal and the member 13 is a simple spring, preferably their resistance is made about equal. The thickness of the solder is as small as it can conveniently be. Preferably, it is materially less than the thickness of one of the members 18 or 19.

The solder used for the joint is one having a sharply defined melting point. An alloy of lead and bismuth known as eutectic lead-bismuth solder is suitable for this use but other fusible alloys can be used.

In the operation of the device, current enters at the cap 3 in Fig. 1 and emerges at the cylindrical element 4. The current is conducted from cap 3 to the rod 6 in a familiar way. From the rod 6 it goes to the ferrule 5 over two paths, one through the wire 10 and the other through the joined connection comprising members 12 and 13. From the ferrule 5 it goes to the cylinder 4 in a familiar way. I have described the path of the current as if its direction were determined. It is obvious, however, that the current may flow in the opposite direction without change in the operation.

Current through the connector 12 heats it. The heating is greatest in the narrow parts of the connector and the heat generated in the parts 12 and 13 reaches the joint between them by thermal conduction. If the current be not greater than that for which the fuse is designed, the heat which reaches the joint is insufficient to melt it. If the current be greater than this, the temperature of parts 12 and 13 rises and the heat which flows therefrom to the joint is enough to melt the solder there. If the current is larger than this, say that corresponding to a short-circuit, the solder is promptly melted and it may even happen that the parts 12 and 13 also are melted.

Heating the solder mainly by thermal conduction from members 12 and 13 takes perceptibly more time than heating a fusible resistance wire directly by the current flowing in it, as is usual in fusible interrupters. Thus a certain delay in the action of the fuse obtains with small overloads such as that of a starting motor.

As the member 12 heats up, the difference in expansion between the portions 18 and 19 causes the member 12 to tend to bend, thus tending to move away from the member 13. Even though no perceptible movement occurs at currents below the value which will fuse the solder in the joint, a considerable stress is introduced by the difference in expansion and a considerable pull upon the soldered joint results. When the current rises to a value which causes the solder to melt, the parts 12 and 13 separate.

There are some solders that change their characteristics upon aging. With such a solder the joint may become unable to withstand the pull of the spring 7 even while unaffected by the current. The wire 10 by taking the strain off the joint prevents any such unexpected separation of the members 12 and 13. Thus their separation at an indefinite time is prevented.

Whether the interruption of current through members 12 and 13 is at a definite moment or at an unpredictable time, when they separate all of the current from the cap 3 to the cylinder 21 passes through the wire 10. Until this time, only a small portion of such current passes through wire 10 because the resistance of this wire is large compared to the resistance of the connected members 12 and 13. When the wire 10 carries all of the current, it is rapidly heated thereby and soon reaches the fusing point.

The wire 10 is preferably the "Nichrome" alloy referred to above having high resistance and a melting point of about 1400° C. Although this is above the temperature at which the boric acid 21 surrounding the rod 6 is affected, no substantial amount of decomposition of the lining is produced mainly because the time during which the wire 10 is being heated up and fuses is so short.

When the wire 10 has been fused there is no longer any mechanical connection between the rod 6 and the ferrule 5, and the rod moves upward under the influence of the spring 7. The movement of the rod 6 draws the arc into contact with the boric acid 21 surrounding the rod and it is decomposed by the heat of the arc producing gases and vapor that assist in extinguishing the arc. The above statement that substantially no boric acid is decomposed by heat from the wire 10 does not negative that it is decomposed by heat from the arc. The action of the arc within the tube and the effect of the supplemental small bore 22 are as described in the above-mentioned patent to Rawlins. The features described herein and not found in said patent include the connections between the rod 6 and the ferrule 5 and the way in which these connections release the rod.

If, instead of bimetal, the members 12' and 13' are leaf springs as shown in Fig. 4, their tendency to separate is the same, but the magnitude of the bias tending to separate them does not increase with the temperature. When the springs get hot enough to melt the solder, the joint opens (as shown in Fig. 4) and all the current passes through the wire 10. The action thereafter is like that already explained.

With either form of the invention the magnitude of the stress on the soldered joint between members 12 and 13 is independent of the stress of the main spring 7 due to the provision of the strain wire 10. The results obtained by this invention thus surpass those obtainable by using a single connection between rod 6 and ferrule 5. If such single connection be of the fusible joint type, the strain impressed by spring 7 must be resisted by the joint unaided and in time it may yield even if no overload occurs. In case of aging solder, if the strain wire 10 were omitted, the action of the fuse would become uncertain.

If the wire 10 be used without the jointed connector it must carry the normal current and therefore must be heated a long time before it fuses. It will thus decompose some of the boric acid before there is any arc for the vapor to act upon. If the overload very slowly brings the temperature of the wire to the value that will fuse it, enough boric acid may be decomposed to leave insufficient to extinguish the arc.

It will occur to those skilled in the art that many modifications in detail come within the spirit of this invention, and the specific description of certain modifications only is not to be regarded as a limitation. The only intentional limitations are those expressed in the claims or required by the prior art.

I claim as my invention:

1. In a circuit interrupter, two conductors, a spring biasing one to departure from the other, two connections joining the conductors, one connection including a fusible joint biased to separate upon the occurrence of predetermined conditions and the cross section of which is great compared with its length, and the other having sufficient mechanical strength to withstand said biasing spring.

2. In a circuit interrupter, two terminal conductors, a spring biasing one of said conductors to move away from the other, two connections joining said conductors, one connection including a fusible joint biased to separate upon the occurrence of predetermined conditions, the cross section of the joint being great compared with its length, and the other connection being of material which fuses at a higher temperature than said joint and has, while unfused, sufficient mechanical strength to withstand said biasing spring.

3. In a circuit interrupter, two terminal conductors, a spring biasing one of said conductors to move away from the other, two connections joining said conductors, the first connection including two members and a fusible joint joining them in series, one of said members having a bias tending to move it away from the other, the second connection being fusible by current therein when the value of said current is as great as that which will fuse the joint in the first connection if carried thereby, said second connection being capable of carrying without fusion the current therein when the first connection is carrying a current insufficient to fuse said joint and said second connector having when unfused sufficient mechanical strength to withstand said biasing spring.

4. In a circuit interrupter, two terminal conductors, a spring biasing one of said conductors to move away from the other, two connections joining said conductors, one connection including two members and a fusible joint joining them in series, one of said members having a bias tending to move it away from the other, said bias being resisted by said joint, said member including thermal-responsive means for controlling said bias, the second connection being fusible by current therein when the value of said current is as great as that which will fuse the joint in the first connection if carried thereby, said second connection being capable of carrying without fusion the current therein when the first connection is carrying a current insufficient to fuse said joint and said second connector having when unfused sufficient mechanical strength to withstand said biasing spring.

5. In a circuit interrupter, two terminal conductors, a spring biasing one of them to move away from the other, two connections in parallel between said conductors, one of said connections having sufficient mechanical strength to hold the terminal conductors together against the action of said bias, said connection being fusible by current therethrough above that normally carried by either connection, and the other connection having a fusible joint of short length and large cross section, said fusible joint having means biasing it to separate at currents above a predetermined value, whereby at currents above said value all the current will be carried by said fusible connection and at currents below said value said fusible connection will carry part only of the current.

6. In a circuit interrupter, a pair of terminals, a spring tending to separate them and two connections uniting them, one of said connections comprising two conductors biased to separate in a direction at an angle to their length, fusible means normally uniting said conductors and having a cross-section at least as great as the adjacent portion of each of said conductors and a specific resistance lower than that of said conductors to provide a predetermined time delay in the fusion of said fusible means upon the occurrence of predetermined conditions.

7. In a circuit interrupter, a pair of terminals, a spring tending to separate them and two connections uniting them, one of said connections comprising two conductors one of which is self-biased to separate said conductors in a direction at an angle to their length, fusible means normally uniting said conductors having a cross-section at least as great as the adjacent portion of each of said conductors and a specific resistance lower than that of said conductors to cause a flow of heat from said conductors to said fusible means for fusing the latter upon the occurrence of predetermined current conditions.

8. In a circuit interrupter, a pair of terminals, a spring tending to separate them and two connections uniting them, one of said connections comprising two conductors, at least one of said conductors being a spring self-biased in response to predetermined temperature conditions to separate the conductors in a direction at an angle to their length, fusible means for normally preventing said separation, said means having a cross-section at least as great as the adjacent portion of each of said conductors and a specific resistance less than that of said conductors to effect a predetermined time delay in the fusion of said fusible means upon the occurrence of predetermined current conditions and the other connection having a greater mechanical strength.

9. In a circuit interrupter, a pair of terminal conductors, bias-producing means tending to separate them, means for preventing said separation, said preventing means including a conductor having a joint with smaller electrical resistance than other portions of said conductor, said conductor affording good thermal conduction between said joint and said other portions, said other portions being biased independently of said bias-producing means to separate at said joint upon the occurrence of predetermined conditions.

10. In a circuit interrupter, a pair of terminal conductors, a spring biasing one of them away from the other, two connections uniting said conductors and preventing movemnt under said bias, the first of said connections comprising two members in series, temperature-responsive biasing means tending to separate said members,

uniting means resisting said separation until the temperature exceeds a predetermined limit and, the other connection having a higher electrical resistance and a higher mechanical strength than the first connection.

11. In a circuit interrupter, current conducting means separable to open the circuit, means responsive to a predetermined current condition to initiate the separation of said conducting means, and said conducting means being biased to separate with a force which increases as said predetermined current condition is approached.

12. In a fuse link, a conductor, a fusible portion in said conductor, and current responsive means for biasing the parts of said conductor to separate upon the melting of said fusible portion.

13. In a fusible link, a metallic strip, a fusible portion in said metallic strip, and one portion of said metallic strip being of bimetallic material for bending to cause separation of the parts of said metallic strip upon melting of said fusible portion.

14. In a fuse, conducting means, a fusible portion in said conducting means, main biasing means for moving the parts of said conducting means apart after melting of said fusible portion, and means independent of said main biasing means for biasing parts of said conducting means to separate.

15. In a fuse, conducting means, a fusible portion in said conducting means, main biasing means for moving the parts of said conducting means apart after melting of said fusible portion, and means independent of said main biasing means for biasing parts of said conducting means to separate, said independent biasing means increasing its biasing force upon an increase in current.

16. In a circuit interrupter, a conductor, a separable portion in said conductor, main biasing means tending to separate the parts of said conductor, and bimetallic means tending to separate parts of said conductor.

17. In a circuit interrupter, a pair of conducting members normally secured together and separable upon the occurrence of predetermined conditions, a spring for applying a biasing force to move one of said conducting members longitudinally, and another means for biasing said conducting means to move laterally apart.

18. In a circuit interrupter, means for establishing an arc including a separable joint, a main biasing spring for moving one part of said means for establishing the arc, means for relieving said separable joint from the stress of said main biasing spring, and said separable joint having means biasing it to separate upon overload.

19. In a circuit interrupter, means for establishing an arc including a separable joint, a main biasing spring for moving one part of said means for establishing the arc, means for relieving said separable joint from the stress of said main biasing spring and said separable joint including a bimetallic member connected in the circuit to be heated by the current flow and bend laterally to separate said joint upon overload.

20. In a circuit interrupter, a tubular closure at least in part of insulating material, a conducting terminal at each end of said tubular closure, conducting means within said tubular closure for normally establishing an electrical circuit between said terminals, said conducting means including two parts joined by fusible means, main biasing means for moving one part of said conducting means away from the other part upon melting of said fusible means to draw an arc within said closure, and means independent of said main biasing means for biasing said parts to separate upon the fusion of said fusible means.

21. In a circuit interrupter, a tubular member at least in part of insulating material and open at one end, a conducting terminal at each end of said tubular member, conducting means for establishing an electrical circuit between said terminals, said conducting means including a movable conducting member, spring means for moving said conducting member away from the terminal adjacent the open end of said tubular member, a fusible strain wire disposed between said tubular member and said terminal for normally restraining said conducting member against movement by said spring means, and a pair of conductors joined by fusible means and disposed in parallel circuit relation with said strain wire, said pair of conductors being biased to separate upon fusion of said fusible means.

22. A circuit interrupter comprising a tubular enclosure open at one end, terminals, at each end of said enclosure, an arc chamber within said enclosure terminating at the open end thereof, a fuse link within said enclosure, said fuse link including a pair of bimetallic conductors, one of which is connected to the terminal adjacent the open end of said enclosure and the other to a movable member which is in turn connected to said other terminal, fusible means joining said bimetallic conductors, said bimetallic conductors being disposed to bend apart upon fusion of said fusible means, and biasing means for moving said movable member through said arc chamber following the separation of said bimetallic conductors.

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