April 9, 1968 B. W. BAUMBACH 3,377,448

THERMAL RESPONSIVE MINIATURE FUSE

Filed Aug. 22, 1966

FIG. 1

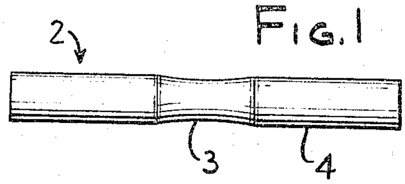


FIG. 2

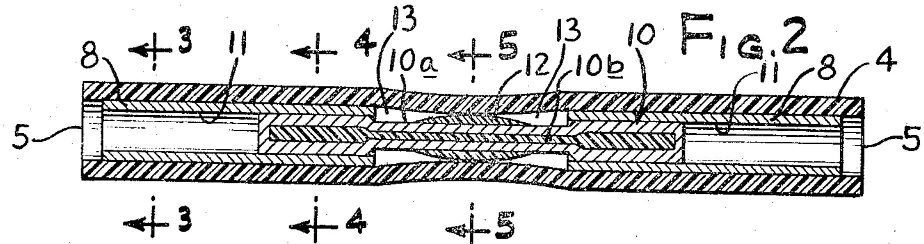


FIG. 3

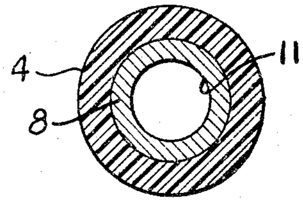


FIG. 4

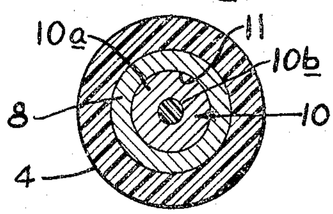


FIG. 5

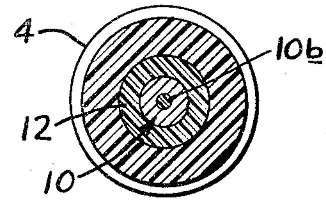


FIG. 6

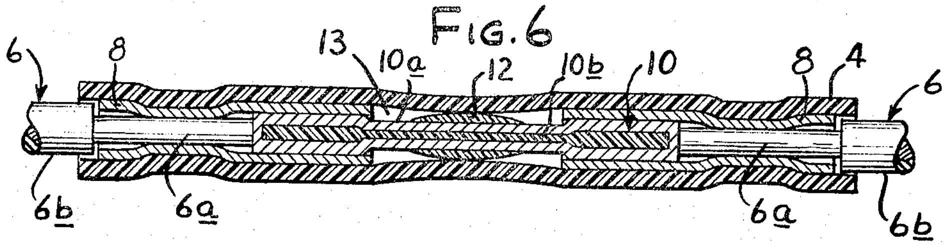
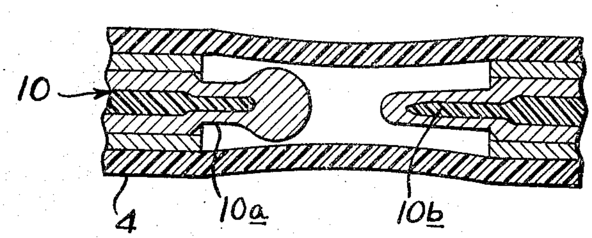


FIG. 7



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THERMAL RESPONSIVE MINIATURE FUSE

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The present invention relates to circuit breakers of the type utilizing a fusible conductive link which melts when overheated to break an electrical circuit.

The most important application of the present invention is in fuses which are responsive to excessive ambient temperature conditions, such as in fuses for small alternating current fractional horsepower motors where it is desired to prevent excessive temperature rise in the field winding due to a blocked rotor or other abnormal condition. As will appear, the fuse of the present invention can be readily made of a diameter comparable to that of the field winding conductors and under an inch long, so it can be placed inside the motor housing adjacent the field winding for greatest efficiency of heat transfer.

One difficulty heretofore encountered in the manufacture of small low cost fuses which are to respond to ambient temperature conditions is the obtainment of fuses with consistently responsive circuit breaking characteristics. Thus, apparently identical fuses subjected to the same ambient temperature conditions frequently open at different times and at different temperatures. Heat is transferred from the external environment to the fuse by conduction, radiation and convection. The time it takes a fuse to reach a given circuit breaking temperature and the temperature at which the fuse melts depends upon a number of factors including the physical relationship between the outer surface of the fuse and the particular source of heat being monitored, and in the variables within the fuse, such as the medium connected between the outside of the fuse and the fusible material therein, the tolerances in the spacing of the fusible material relative to the outer surface of the fuse and the surface tension conditions of the fusible material when it melts.

One of the objects of the invention is to provide a small sized low cost fuse usable, for example, in small sized motors where it can be readily placed within the motor housing next to the field winding. A related object of the invention is to provide a fuse as described which is designed to conduct heat quickly and efficiently to the fusible element therein and which opens at a consistent predetermined temperature under all expected operating conditions.

Another object of the invention is to provide a fuse which is designed readily to be connected between the bared ends of a pair of conductors in a simple and easy manner which does not require any soldering, screw turning or insulation applying operations to install the fuse.

Still another object of the invention is to provide a fuse as described wherein the time required to heat the fusible element therein is minimized.

A further object of the invention is to provide a fuse which accomplishes in a single, compact, low cost fuse all of the aforementioned objectives.

In accordance with one aspect of the invention, the fuse is provided with a solid fusible conductive link between the terminals thereof and a surface tension reducing material at the portion of the fusible conductive link which is first expected to melt, the surface tension reducing material reducing the surface tension of the melted fusible conductive link to a point where the surface tension does not become a significant factor affecting the temperature at which the fusible material separates to break the circuit involved. The most effective use of the surface tension reducing material is obtained when it forms a solid body of material around the fusible conductive link and bridges the space between the link and an outer enclosure or casing. It is also most advantageous that a surface tension reducing material be embedded within the central portion of the fusible conductive link.

It has been found that rosin flux, in addition to its well known oxide dissipating qualities, acts as an especially good surface tension reducing material for lead type solders which may be used as the material out of which the link is made. To be effective, the flux on the outside of the link should form a relatively thick layer around the central portion of the link when the solder melts. The fluxes generally used with solder for wire soldering purposes having a melting temperature substantially below the melting temperature of the solder. In such case, when the temperature of the flux rises to its melting temperature, the flux will run off and be ineffective at the point where it is needed unless the flux is confined in a limited space where the desired thickness of the flux is maintained about the portion of the link which first melts. In accordance with an aspect of the invention, a flux composition is used which remains in a solid or non-flowable state (that is, it maintains its bodily contour or integrity despite clearance for its flow at temperatures) up to and including the desired melting temperature of the fusible conductive link.

Where the body of surface tension reducing material around the portion of the fusible conductive link which is expected to melt first bridges the space between the fusible conductive link and an outer enclosure or casing the body of surface tension reducing material can act as an excellent conductor of heat from the outside of the fuse to the fusible conductive link, and also acts as a means for centering the fusible conductive link with respect to the insulating sleeve. All parts of the fuse preferably have a circular cross section so the unit is symmetrical in all directions.

A still further aspect of the invention is in providing the ends of the fuse with a pair of hollow conductive terminals. The fusible conductive link extends between the inner spaced ends of the hollow terminals and the outer insulating sleeve extends for the full length of the fuse and preferably somewhat beyond the ends of the hollow terminals. The insulating sleeve is made of a flexible material and the hollow terminals are made of a deformable conductive material, such as copper or aluminum, which can be crimped around the bared ends of a pair of conductors between which the fuse is placed. The hollow terminals are open at their outwardly facing ends to form sockets for receiving the bared ends of the conductors which are fixedly anchored to the fuse by the crimping of the hollow terminals therearound to make physical and electrical contact with the conductors. The conductors have insulation which terminates within the hollow terminals so that no insulation need be added between the conductors and the fuse of the preferred form of the invention.

The above and other objects, advantages and features of the invention will become apparent upon making reference to the specification to follow, the claims and the drawings wherein:

FIG. 1 is a side elevational view of a fuse constituting the preferred form of the present invention;

FIG. 2 is an enlarged longitudinal sectional view through the fuse of FIG. 1;

FIGS. 3 through 5 are transverse sectional views respectively taken along the correspondingly numbered section lines 3—3, 4—4 and 5—5 in FIG. 2;

FIG. 6 is an enlarged longitudinal sectional view of the fuse of FIG. 1, after the fuse has been connected to a pair of conductors; and

FIG. 7 is an enlarged fragmentary sectional view of the interior of the fuse after it has been subjected to a circuit breaking temperature.

Referring now to FIG. 1, the fuse **2** thereshown is in the general shape of a narrow elongated cylinder except for a narrow central indented portion **3**. The exterior surface of the unit illustrated is constituted completely by a sleeve **4** of flexible insulating material which, in the preferred form of the invention, is shrunk over the interior parts of the fuse to be described. Where the fuse is constructed to protect against overheating of small fractional horsepower motors, the fuse could be under one inch in length and have an outer diameter of the order of one tenth of an inch or less. The ends of the fuse are open at **5—5** (FIG. 2) to receive a pair of insulated conductors **6—6** (FIG. 6) which can be anchored to the fuse by simply crimping the ends of the unit around the insulated conductors **6—6**. The end portions of the insulating sleeve **4** surround a pair of cylindrical open-ended hollow metal terminals or ferrules **8—8** which, in the illustrated in-line embodiment of the invention, are in axial alignment. The sleeve **4** preferably extends beyond the outer margins of the ferrules.

A fusible conductive link, generally indicated by reference numeral **10**, extends between the inner end portions of the ferrules **8—8**. The fusible conductive link may comprise a cylindrical piece **10*a*** of lead-solder having a rosin flux core **10*b***. In the case where the fuse has a small diameter as above indicated, the link **10** has a very small diameter and can be described as a filament. The illustrated solder piece has a smaller diameter than the diameter of longitudinal sockets **11—11** within the ferrules, and is anchored tightly within the inner ends of the ferrules by compacting the ends of the solder piece as by inserting a punch inside each ferrule and pushing against the ends of the solder with the same. When the end of the solder is squeezed by the punch, the solder seals or encloses the ends of the flux core as shown in the drawings.

The fusible conductive link **10** occupies only a fraction of the length of the ferrule sockets so that the sockets readily can receive the bared ends of the conductors **6—6**. As shown in FIG. 6, each insulated conductor **6** comprises one or more wire strands **6*a*** of conductive material covered with a layer **6*b*** of insulating material which has a diameter somewhat less than that of the ferrule socket **11** so that the insulated conductor **6** can easily be inserted into the ferrule. The insulation layer **6*b*** terminates just inside the insulating sleeve **4** to bare the ends of the wire **6*a*** which is tightly engaged by the associated crimped ferrule. It is apparent that no exposed conductive surfaces are present requiring insulation.

The portion of the fusible conductive link **10** extending between the ferrules **8—8** is spaced from the insulating sleeve **4** and is held in centered relation with respect thereto until the link flows by a body of heat conducting and surface tension reducing material **12**. As illustrated, the body of the surface tension reducing material **12** forms an annular outwardly tapering protuberance having a portion of maximum diameter engaged by the insulating sleeve **4** and end portions of reduced diameter on opposite sides thereof. The particular shape and extent of the body of surface tension reducing material may vary widely, but the shape illustrated is suitable for fuses where the insulating sleeve **4** is applied by shrinking the same in place, for it ensures that the sleeve will engage the body of surface tension reducing material and will leave sufficient clearance spaces **13—13** between the insulating sleeve **4** and the fusible conductive link **10** to enable the melted solder to flow outwardly when the solder melts beyond the ends of the yet non-flowable body of surface tension reducing material.

The body of surface tension reducing material **12** in

the preferred form of the invention may be a rosin flux composition which remains in a non-flowable state at least up to and including the melting temperature of the solder or other fusible material used in the fuse. Thus, unlike most flux materials which melt below the melting temperatures of the solders with which they are used, the main body of the flux will be non-flowable at the melting temperature of the solder so the flux maintains its integrity where it can act as a good heat transferring and link centering medium for temperatures up to the flowing point of the solder and so it can serve a surface tension reducing function at the point where the solder is ready to flow. For most effective results, the surface tension reducing material **12** has a thickness at least comparable to that of the solder, as illustrated. The flux core **10*b*** of the solder preferably has a melting temperature below that of the solder **10*a*** with which it is used. The flux core **10*b*** cannot flow away from the central portion of the solder where it is needed.

When the fuse **2** is used as a fuse for a motor winding, the fuse, after its connection to the conductors **6—6** is held in physical contact with the field windings by fish paper, which is usually part of the motor field construction. When fishpaper is not available, the fuse can be held in place with a drop of epoxy or other suitable adhesive.

When the fuse **2** is subject to an ambient temperature sufficiently great to require a circuit interruption, heat will be transferred through the body **12** of surface tension reducing material to melt the solder **10*a*** surrounded thereby. The outer ends of the solder **10*a*** within the ferrules **8—8** will not melt through first because there is here a greater thickness of material to melt and there are heat absorbing elements nearly not present at the center of the fuse. When the solder melts through to a point at the ends of the flux, the surface tension reducing material around the solder and its flux core will reduce the surface tension of the solder to such an extent that the fusible material flows outwardly quickly to open the electrical circuit involved. As previously indicated, normal liquid solder without substantial amounts of rosin flux or other surface tension reducing material tends to become stringy and is reluctant to separate from itself due to surface tension.

It should be understood that numerous modifications may be made in the most preferred form of the invention described above without deviating from the broader aspects of the invention.

I claim:

1. A thermal protector switch unit comprising: an outer open-ended insulating sleeve, a pair of hollow terminals open at their ends and fixed in place at the opposite ends of and inside of said insulating sleeve in spaced apart relation, a solid fusible conductive link within said insulating sleeve physically and electrically connected by telescoping into the inner ends of said terminals, said conductive link melting at a given temperature to break an electrical circuit, said hollow terminals being covered by said insulating sleeve so that there are no longitudinally exposed conductive surfaces thereon, and said hollow terminals defining conductor-receiving sockets opening onto the ends of the insulating sleeve to receive the bared ends of a pair of conductors to be electrically connected by the switch unit, and said insulating sleeve being inwardly deformable and said hollow terminals being permanently crimpable snugly around the bared ends of the conductors for fixedly securing the switch unit to the conductors.

2. The thermal protector switch unit of claim **1** wherein said insulating sleeve extends beyond the ends of said hollow terminals.

3. The thermal protector switch unit of claim **1** in combination with a pair of conductors extending into said hollow terminals, said conductors having a layer of insulating material surrounding the same which insulating

material terminates within said hollow terminals short of the ends of the conductors to expose the conductors which are snugly engaged by the interior walls of said hollow terminals crimped thereover.

4. A miniature heat fuse to be responsive to ambient temperature conditions comprising: a pair of spaced apart terminals to be connected into an external electrical circuit, a fusible conductive filament which melts at a given temperature and electrically connected and physically extending between said spaced terminals, said fusible filament having a core of surface tension reducing material therein which has a melting temperature below that of the filament, a body of surface tension reducing material on the outside of the portion of the fusible filament which is to melt and spaced inwardly of said terminals, said body of surface tension reducing material on the outside of the filament having a melting temperature above that of the fusible filament so it remains intact until the fusible filament flows and being effective to receive surface tension when the filament is to flow, and enclosure forming means around the fusible filament which enclosure forming means seals the fusible filament and surface tension reducing material from the surrounding air and leaves clearance spaces which permit outward flow of the melted filament.

5. The miniature heat fuse of claim **4** wherein the surface tension reducing material on the outside of the fusible filament has a thickness of at least the order of magnitude of the thickness of the portion of the fusible conductive filament which it surrounds.

6. A miniature heat fuse to be responsive to ambient temperature conditions comprising: a pair of spaced apart terminals to be connected into an external electrical circuit, a fusible conductive filament which melts at a given temperature electrically connected and physically extending between said spaced terminals, a body of surface tension reducing material on the outside of the portion of the fusible filament which is to melt and spaced inwardly of said terminals, said body of surface tension reducing material on the outside of the filament having a melting temperature above that of the fusible filament so it remains intact until the fusible filament flows and being effective to reduce surface tension when the filament is to flow, and enclosure forming means around the fusible filament which enclosure forming means seals the fusible filament and surface tension reducing material from the surrounding air and leaves clearance spaces which permit outward flow of the melted filament, said body of surface tension reducing material on the outside of the fusible filament bridging the space between said filament and said enclosure forming means so the body of surface tension reducing material which remains intact up to the flowing point of the fusible link also forms a heat conducting and filament centering means.

7. A thermal protector switch unit comprising: an outer open-ended insulating sleeve, a pair of hollow terminals open at their ends and fixed in place at the opposite ends of and inside of said insulating sleeve in spaced apart relation, a fusible conductive link within said insulating sleeve physically and electrically connected between said terminals by telescoping into the inner ends of said terminals, said conductive link melting at a given temperature, said hollow terminals being covered by said insulating sleeve so that there are no longitudinally ex- of the hollow terminals, to leave spaces within the insulat- posed conductive surfaces thereon, said hollow terminals defining conductor-receiving sockets opening onto the ends of the insulating sleeve to receive the bared ends of a pair of conductors to be electrically connected by the switch unit, said outer insulating sleeve being made of a shrinkable material which has been shrunk tightly around said hollow terminals, said solid fusible conductive link having thereon a surrounding outwardly tapering protuberance of a solid surface tension reducing material having portions near the outer ends thereof which terminate radially inwardly of the periphery of the adjacent ends ing sleeve when the sleeve is shrunk therearound.

8. The heat fuse of claim **4** wherein said core of surface tension reducing material in said fusible filament is sealed within the filament so it cannot touch or migrate to said terminals.

9. A thermal protector switch unit comprising: an outer-ended insulating sleeve, a pair of hollow terminals open at their ends and fixed in place at the opposite ends of and inside of said insulating sleeve in spaced apart relation, a fusible conductive link within said insulating sleeve physically and electrically connected between said terminals by telescoping into the inner ends of said terminals, said fusible link having a core of surface tension reducing material which melts below the temperature at which said fusible link will flow, the ends of said fusible link being squeezed inwardly from the ends thereof to expand the link into tight fitting relationship with said hollow terminals and seal the core of surface tension reducing material within the filament, said hollow terminals defining conductor-receiving sockets opening onto the ends of the insulating sleeve to receive the bared ends of a pair of conductors to be electrically connected by the switch unit.

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