May 18, 1954 P. C. HITCHCOCK 2,678,980

THERMAL PROTECTION OF CABLES

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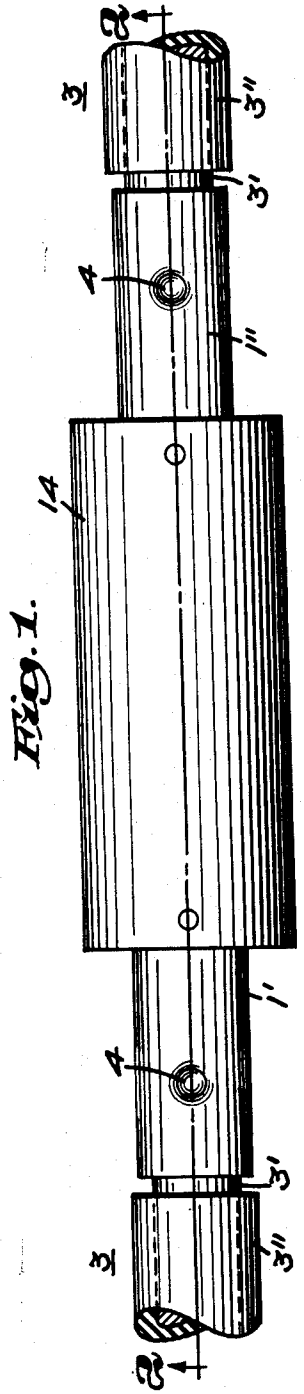


Fig. 1.

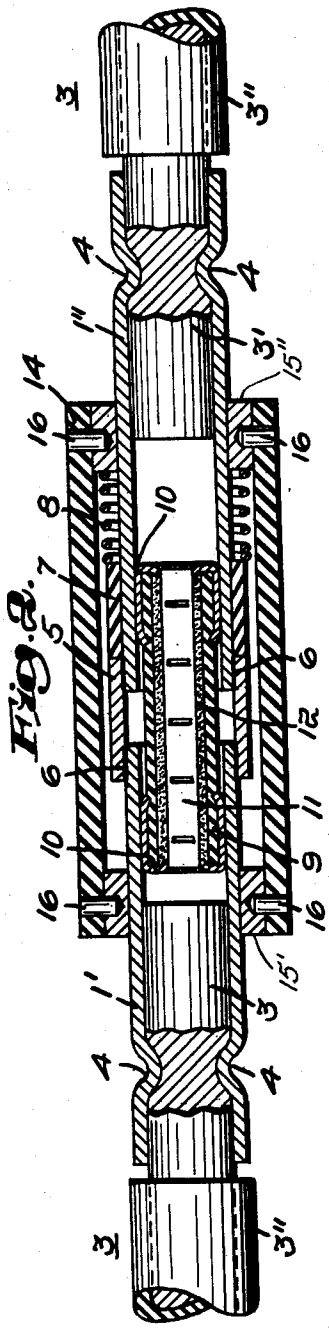


Fig. 2.

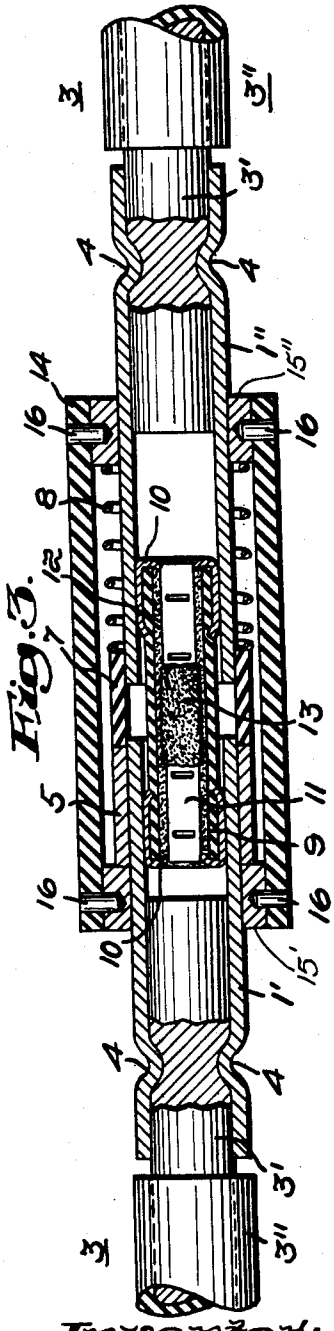


Fig. 3.

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THERMAL PROTECTION OF CABLES

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8 Claims. (Cl. 200—114)

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This invention refers to arrangements for the protection against overheating of the insulation of insulated electric conductors such as, for instance, electric cables.

An arrangement which is based on the same principles as my present invention is disclosed in the copending patent application of William S. Edsall and Paul C. Hitchcock, Ser. No. 222,658, filed April 24, 1951, now U. S. Patent No. 2,645,690, dated July 14, 1953, for Thermal Protector for Conductor Insulation.

It is one object of my present invention to provide an arrangement for the protection against overheating of the insulation of insulated electric conductors which has all the advantages of the arrangement disclosed in the above referred-to copending patent application but is easier to manufacture and can be manufactured at considerably lower cost.

Another object of my present invention is to provide an arrangement for the protection against overheating of the insulation of electric conductors which has all the advantages of the arrangement disclosed in the above referred-to copending patent application but is easier to install and to replace.

Another object of my invention is to provide a thermal cable protector controlled by, and directly responsive to, the $i^2.r$ losses occurring in an associated cable comprising elements having the multiple function of cable connectors and of fixed contact members and supports for a relatively movable cooperating contact member.

Another object of my invention is to provide a thermal cable protector made up substantially of tubular inexpensive easy-to-produce parts.

A further object of my invention is to provide a thermal cable protector of the type having cooperating contacts relatively movable in a direction longitudinally of the protector and normally restrained in the closed position comprising an insulating follower which fills progressively the interrupting gap which forms progressively as said contacts move apart.

Other objects and advantages of my invention will become apparent as this specification proceeds and the features of novelty of my invention are being pointed out with particularity in the claims appended to and forming part of this specification.

For a better understanding of my invention reference may be had to the accompanying drawing wherein:

Fig. 1 is a side elevation of a structure embodying my invention,

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Fig. 2 is substantially a longitudinal cross-sectional view of the structure shown in Fig. 1 the constituent parts thereof being in the circuit closed position, and

Fig. 3 is substantially a longitudinal cross-sectional view of the structure shown in Figs. 1 and 2, the constituent parts thereof being in the circuit open position.

In the drawing reference numerals 1' and 1'' have been applied to a pair of coaxially arranged spaced substantially cylindrical preferably tubular conductors. The cable generally indicated by the reference numeral 3 comprises the inner core portion 3' and the enveloping insulating portion 3''. Cable 3 is subdivided into two spaced sections of which each has a terminal from which the insulation has been stripped. The juxtaposed bare portion or terminals of cable 3 are inserted into the tubular conductors 1' and 1'', respectively. Conductors 1' and 1'' are indented at 4 by means of a suitable high pressure tool, such as a hydraulic press, to establish a firm mechanical connection and a highly conductive bond between the bare ends of core 3' and conductors 1' and 1''. Conductors 1' and 1'' are preferably made up of copper tubing. A tubular current-bridge 5 is mounted coaxially on conductors 1' and 1'' to carry current from one conductor to the other. The right end of conductor or connector 1' and the left end of conductor or connector 1'' are coated with a suitable soft low melting point solder, e. g. a solder of the kind fully disclosed in the aforementioned copending Patent No. 2,645,690. These solder coatings indicated by the reference numeral 6 form conductive connections between conductor 1' and current-bridge 5 and between current-bridge 5 and conductor 1''. Solder joints 6 restrain normally the current-bridge 5 in the bridging position thereof, i. e. in the position shown in Fig. 2 wherein conductors 1' and 1'' are conductively interconnected by current-bridge 5. Both solder joints 6 are preferably cylindrical or toroidal in the form of a fusible film filling the narrow gaps formed between conductor 1' and current-bridge 5, and between conductor 1'' and current-bridge 5, respectively.

The above referred-to cylindrical solder joints 6 can best be produced by dipping the ends of conductors 1' and 1'' into liquid solder prior to the assembly of these two parts in the present structure and reheating the solder coating thus produced upon mounting of the current-bridge 5 on conductors 1' and 1''.

The tubular insulating element 7 consisting of

hard fibre or a like material is slidably mounted on conductor 1'' in abutting relation to current-bridge 5. The helical spring 8 is likewise mounted on conductor 1'' and biases both the current-bridge 5 and the insulating element or insulating follower 7 from right to left as seen in Fig. 2.

The length of the tubular insulating follower 7 exceeds the spacing between the juxtaposed ends of conductors or connectors 1', 1'', as clearly shown in Fig. 3, so as to fill the entire gap formed between the juxtaposed ends of the parts 1' and 1'' with insulating material when the solder joints 6 normally restraining bridge 5 become sufficiently soft to yield to the pressure of helical spring 8.

The tubular insulating spacer 9 is pressed or rammed into the juxtaposed ends of connectors 1' and 1'' to maintain the proper spacing between these two parts. Because of this function of spacer 9 this element ought to be made of a material having a high degree of dimensional stability, even under adverse heating conditions. Tubular insulating spacer 9 may be made of a synthetic resin-glass-cloth-laminate which retains its original dimensions even if subjected to the most adverse conditions that may be encountered.

As shown in Figs. 2 and 3, the tubular insulating spacer 9 may be provided with a pair of caps or terminal elements 10 closing the spacer 9 and each in electric contact with one of the two conductors 1', 1''. Fusible link 11 arranged within spacer 9 interconnects conductively the pair of caps or terminal elements 10. A pulverulent arc-quenching filler 12 as, for instance, quartz sand is arranged within spacer 9 and surrounds the fusible link 11. Fusible link 11 consists preferably of silver or copper and is provided with a plurality of equidistantly spaced portions of reduced cross-section which form series breaks when the link 11 is caused to carry a current greatly exceeding its current-carrying capacity.

The tubular current-bridge 5 shunts normally the current path comprising connector 1', left terminal cap 10, fuse link 11, right terminal cap 10 and connector 1''. Since the current-carrying capacity and conductance of the current-bridge or shunting element 5 exceeds by far the current carrying capacity and conductance of fuse link 11, normally virtually all the current carried by cable 3 flows through the shunt path 5 and virtually no current flows through the parallel current path comprising the fusible link 11. On occurrence of heavy loads of excessive duration endangering the insulation 3'' of cable 3 or causing evolution of smoke therefrom, solder joints 6 become sufficiently heated to yield to the action of spring 8. As a result, current-bridge 5 and insulating sleeve 7 are jointly moved by spring 8 from their normal position shown in Fig. 2 to the off-position shown in Fig. 3. No arcing occurs as current-bridge 5 parts from connector 1'' because at this very moment the potential of both connectors 1' and 1'' is equal by virtue of their interconnection by fusible shunt 11. The gap forming between current-bridge 5 and connector 1'' is being progressively filled in with solid insulating material as it is being formed, i. e. as its length increases. Therefore there is little or no tendency of kindling of an arc between current-bridge 5 and connector 1''. At the instant current-bridge 5 parts from connector 1'' fuse link 11 begins to carry current; but fuse link 11 is wholly inadequate to carry a current in the order which is normally

being carried by current-bridge 5, and therefore the fuse link 11 fuses and vaporizes almost instantly upon parting of current-bridge 5 from connector 1''. This results in the formation of an arc, yet this arc is safely confined within the pressure resistant tubular spacer 9 and rapidly extinguished by the heat dissipating action of the pulverulent arc-quenching filler 12. Thus the circuit of cable 3 is ultimately interrupted by the formation of a gap within the spacer 9. The ultimate interruption of the circuit of cable 3 has been indicated in Fig. 3 by a fulgurite 13 taking the place of that portion of link 11 that has been destroyed by arcing.

The protector proper as above described is preferably arranged in a tubular housing to which the reference numeral 14 has been applied. Housing 14 is supported by a pair of collars 15', 15'' fixedly mounted on connector 1' and connector 1'', respectively. Housing 14 has an internal diameter equal to the external diameter of collars 15' and 15'' and is thus closed at the axially outer ends thereof by means of collars 15' and 15''. Transverse pins 16 establish a firm connection between housing 14 and collars 15' and 15''. The right end of helical spring 8 mounted on connector 1'' abuts against collar 15 and at the left end of spring 8 rests against the aforementioned slidable insulating collar 7.

The yielding point of solder joints 6 is below the critical temperature which, if continuously maintained, would endanger the insulation 3'' of cable 3 or result in the evolution of smoke therefrom. The electrical and the thermal characteristics of connector studs 1' and 1'', current-bridge 5 and solder joints 6 and the electrical and thermal characteristics of cable 3 are so correlated that the temperature at the points where the solder joints 6 are situated never exceeds the temperature at any point of the cable remote from the solder joints 6. Thus an operating characteristic can readily be achieved which is an inverse time-current characteristic closely following the insulation danger characteristic or smoke evolution characteristic of cable 3 throughout the entire overload range thereof. This has been shown in considerable detail in the above referred-to copending Patent No. 2,645,690 to which reference may be had as to the exact relation between the insulation danger characteristic or the smoke evolution characteristic of a cable and the operating characteristic of protective devices of the present nature.

The resistance of the current path formed by connectors 1' and 1'', by current-bridge 5 and solder joints 6 is sufficiently low to cause the temperature of solder joints 6 to be preponderantly governed by $i^2 \cdot r$ losses in cable 3 and to be relatively unaffected by $i^2 \cdot r$ losses occurring in the portion of the circuit situated between the bare terminals of cable 3. The thermal characteristics of connectors 1' and 1'', current-bridge 5 and solder joints 6 and the thermal characteristics of cable 3 are so correlated that the temperature at any point of said portion of the circuit of cable 3 never exceeds the temperature at any point of the core 3'' of cable 3.

While I prefer to arrange a fuse structure within the spacer 9, it is possible in many instances to omit that fuse structure and to rely solely on the interrupting capacity inherent in parting of the current-bridge 5 from connector 1'' and the operation of the associated follower 7. Presence of the fuse structure in spacer 9 greatly increases the overall interrupting capacity of the

device; but where both the circuit voltage and the recovery voltage are relatively low, the fuse structure within spacer 9 can safely be omitted as shown by tests made with structures identical with that shown in Figs. 1 to 3 except for the omission of fuse link 11.

Having disclosed the preferred embodiment of my invention, it is desired that the same be not limited to the particular structure disclosed. It will be obvious to any person skilled in the art that many modifications and changes may be made without departing from the broad spirit and scope of my invention. Therefore, it is desired that the invention be interpreted as broadly as possible and that it be limited only as required by the prior state of the art.

I claim as my invention:

1. An arrangement for the protection against overheating of the insulation of a cable in an electric circuit comprising a pair of coaxial fixedly spaced conductors, a current-bridge mounted on said pair of said conductors to carry current from one of said pair of conductors to the other of said pair of conductors, a pair of low fusing point metal means conductively connecting said current-bridge to each of said pair of conductors and normally restraining said current-bridge in the bridging position thereof, a tubular insulating element mounted on one of said pair of conductors in abutting relation to said current-bridge, and a helical spring mounted on said one of said pair of conductors for biasing said current-bridge in the direction toward said other of said pair of conductors.

2. An arrangement for the protection against overheating of the insulation of an electric conductor in an electric circuit comprising a pair of coaxial fixedly spaced tubular connectors adapted to receive at opposite ends thereof bare terminals of a cable to be protected, an annular current-carrying element mounted on said pair of connectors and bridging the gap formed therebetween, a pair of substantially annular solder joints each conductively connecting one end of said annular element to one of said pair of connectors and normally restraining said annular element in the bridging position thereof, a tubular insulating element of greater length than said gap formed between said pair of connectors in abutting relation to said annular element, and a helical spring mounted on one of said pair of connectors biasing said annular element in the direction toward the other of said pair of connectors.

3. An arrangement for the protection against overheating of the insulation of a cable in an electric circuit comprising a pair of coaxial spaced substantially cylindrical conductors hollow at the juxtaposed ends thereof, an insulating spacer inserted into said hollow ends of said pair of conductors to secure the spacing thereof, a tubular current-bridge coaxially mounted on said pair of conductors to carry current from one of said pair of conductors to the other of said pair of conductors, a pair of solder joints each conductively connecting one end of said current-bridge to one of said pair of conductors and normally restraining said current-bridge in the bridging position thereof, a tubular insulating element of greater length than the spacing of said pair of conductors mounted on one of said pair of conductors in abutting relation to said current-bridge, and a spring biasing said current-bridge in a direction longitudinally thereof away from said one of said pair of conductors.

4. An arrangement for the protection against overheating of the insulation of a cable in an electric circuit comprising a pair of coaxially arranged spaced substantially cylindrical conductors hollow at the juxtaposed ends thereof, a tubular insulating spacer projecting into said hollow ends of said pair of conductors to preclude relative movement thereof, a pair of terminal elements closing said spacer each in electric contact with one of said pair of conductors, a fusible link arranged within said spacer conductively interconnecting said pair of terminal elements, a pulverulent arc-quenching filler arranged within said spacer surrounding said fusible link, a tubular shunting element of higher current-carrying capacity than said fusible link coaxially mounted on said pair of conductors to shunt the current path through said fusible link, a pair of solder joints each conductively connecting one end of said shunting element to one of said pair of conductors and normally restraining said shunting element in the shunting position thereof, and a spring biasing said shunting element in a direction longitudinally thereof out of engagement with one of said pair of conductors.

5. An arrangement for the protection against overheating of the insulation of an electric conductor in an electric circuit comprising a pair of coaxially arranged spaced tubular connectors adapted to receive at the remote ends thereof the bare terminals of a cable to be protected, a tubular insulating spacer projecting into the juxtaposed ends of said pair of conductors to secure the spacing thereof, a pair of metallic terminal elements closing the ends of said spacer each conductively engaging the inside of one of said pair of connectors, a fusible link arranged within said spacer conductively interconnecting said pair of terminal elements, a pulverulent arc-quenching filler arranged within said spacer and surrounding said fusible link, a tubular shunting element of higher current-carrying capacity than said fusible link coaxially mounted on said pair of connectors to shunt the current path of said fusible link, a pair of substantially annular solder joints each conductively connecting one end of said shunting element to one of said pair of connectors and normally restraining said shunting element in the shunting position thereof, an insulating collar of greater length than the spacing of said pair of connectors mounted on one of said pair of connectors in abutting relation to said shunting element, and a spring biasing said collar in a direction longitudinally of said pair of connectors away from said one of said pair of connectors.

6. An arrangement for the protection against overheating of the insulation of an electric cable in an electric circuit comprising a pair of coaxially arranged spaced substantially cylindrical conductors hollow at the juxtaposed ends thereof, a tubular insulating spacer projecting into said hollow ends of said pair of conductors to fix the spacing thereof, a pair of terminal caps closing the ends of said spacer each conductively engaging the inside of one of said pair of conductors, a fusible link arranged within said spacer conductively interconnecting said pair of terminal caps, arc-quenching means within said spacer for quenching the arc incident upon fusion of said link, a tubular shunting element of higher current-carrying capacity than said fusible link coaxially mounted on said pair of conductors to shunt the current path through said

fusible link, a pair of solder joints each conductively connecting one end of said shunting element to one of said pair of conductors and normally restraining said shunting element in the shunting position thereof, a pair of spaced collars each fixedly mounted on one of said pair of conductors, an insulating casing mounted on and axially closed by said pair of collars, an insulating collar slidably mounted on one of said pair of conductors in abutting relation to said shunting element, and a helical spring mounted on one of said pairs of conductors in abutting relation to one of said pair of collars and to said insulating collar.

7. An arrangement for the protection against overheating of the insulation of a cable in an electric circuit comprising an electric circuit, a cable inserted into said circuit, a tubular housing arranged adjacent said cable, a pair of fixedly spaced studs coaxially arranged within said housing, a tubular current-bridge coaxially mounted on said pair of studs to carry current from one of said pair of studs to the other of said pair of studs, a pair of solder joints conductively connecting each of said pair of studs to said current-bridge and normally restraining said current-bridge in the bridging position thereof, the yielding point of said pair of solder joints being below the critical temperature which if continuously maintained would endanger the insulation of said cable, said pair of studs said current-bridge said pair of solder joints and said cable being serially inserted into said circuit, the electrical and the thermal characteristics of said pair of studs said current-bridge and said pair of solder joints and the electrical and thermal characteristics of said cable being so correlated that the temperature of said pair of solder joints never exceeds the temperature at any point of said cable remote from said pair of solder joints, an insulating element slidably mounted on one of said pair of studs in abutting relation to said current-bridge, and a helical spring mounted on said one of said pair of studs for biasing said current-bridge in a direction longitudinally of said housing to interrupt the flow of current through said current-bridge upon reaching said yielding point by said pair of solder joints.

8. An arrangement for the protection against overheating of the insulation of a cable comprising an electric circuit, a cable inserted into said circuit, a tubular housing arranged adjacent said cable, a pair of coaxially arranged spaced substantially cylindrical conductors hollow at the immediately adjacent ends thereof, a tubular insulating spacer projecting into said hollow ends of said pair of conductors to fix the position thereof in space, a pair of terminal caps closing said spacer each in electric contact with the internal surface of one of said pair of conductors, a fusible link arranged within said spacer conductively interconnecting said pair of terminal caps, arc-quenching means arranged within said spacer for quenching the arc incident upon fusing of said link, a tubular shunting element of higher current-carrying capacity than said link coaxially mounted on said pair of conductors to shunt the current path of said link, a pair of solder joints each conductively connecting one end of said shunting element to one of said pair of conductors and normally restraining said shunting element in the shunting position thereof, the yielding point of said pair of solder joints being below the critical temperature which if continuously maintained would endanger the insulation of said cable, the resistance of the current path formed by said pair of conductors, said shunting element and said pair of solder joints being sufficiently low to cause the temperature of said pair of solder joints to be governed preponderantly by $i^2 \cdot r$ losses in said cable and to be relatively unaffected by $i^2 \cdot r$ losses occurring in said pair of conductors, said shunting element and said pair of solder joints, the thermal characteristics of said cable and the thermal characteristics of said pair of conductors, said shunting element and said pair of solder joints being so correlated that the temperature at any point of said pair of conductors, said shunting element and said pair of solder joints never exceeds the temperature at any point of said cable, an insulating element slidably mounted on one of said pair of conductors in abutting relation to said shunting element, and a helical spring mounted on one of said pair of conductors for biasing said shunting element in a direction longitudinally of said housing to interrupt the flow of current through said shunting element upon reaching said yielding point by said pair of solder joints.

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