Dec. 18, 1962 F. L. CAMERON 3,069,520

ELECTRIC FUSE CONSTRUCTION

Filed Dec. 10, 1959

Fig. 1

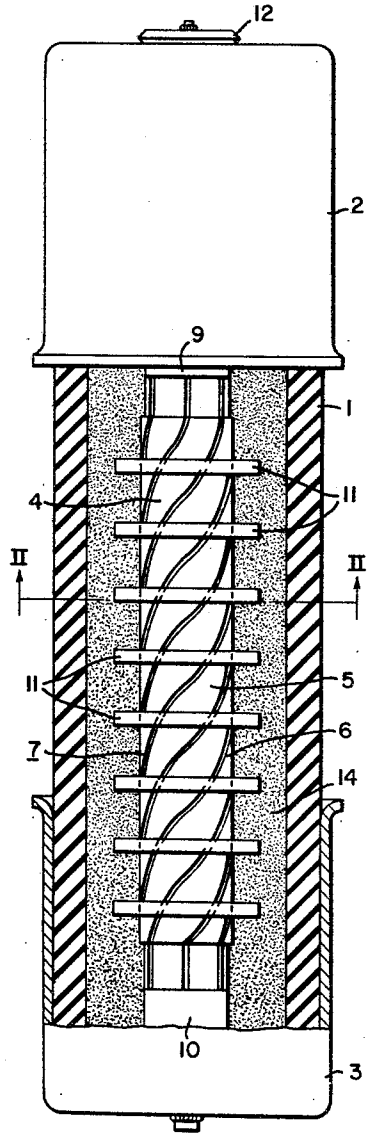


Fig. 2

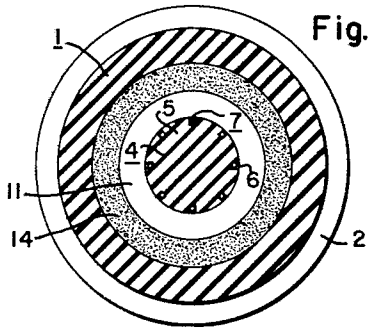


Fig. 3

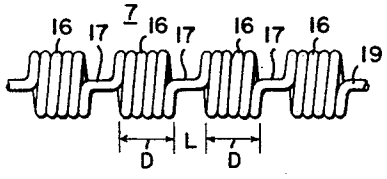


Fig. 4

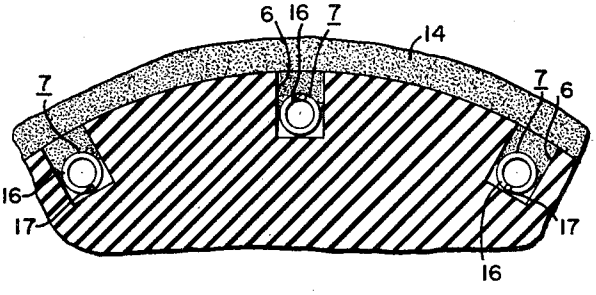


Fig. 5

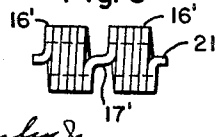
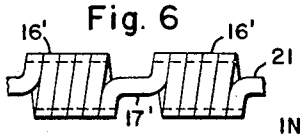


Fig. 6



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3,069,520

ELECTRIC FUSE CONSTRUCTION

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9 Claims. (Cl. 200—120)

This invention relates to electric circuit-interrupting devices in general, and, more particularly, to electric fuse constructions.

In United States Patent 2,502,992 issued April 4, 1950 to Herbert L. Rawlins and Harold H. Fahnoe, and in United States Patent 2,496,704 issued February 7, 1950 to Harold H. Fahnoe, both patents being assigned to the assignee of the instant application, there is set forth. and claimed, a particular type of fuse, known as a current-limiting fuse. This type of fuse consists of a plurality of fusible notched fuse wires connected in electrical parallel, and disposed in a plurality of slots, or grooves, provided on the outside surface of an insulating rod. The rod extends axially of the fuse with the fuse wires being disposed within the longitudinally extending slots on the surface of the rod. The ends of the notched fuse wires are electrically connected to terminal discs, the latter being in turn connected to the terminal caps of the fuse, usually by means of some indicating structure, which will indicate when the fuse has blown.

To absorb the energy created during blowing of the fuse, an inert mass of finely divided material, such as sand, was disposed in proximity to the notched fuse wires. When such fuses were applied to circuits which were repeatedly switched on and off, as in motor-starting service, difficulty has been encountered by reason of breakage of the notched fuse wires. It has been found that the repeated heating and cooling of the notched silver fuse wires caused them to expand and contract in the grooves and resulted occasionally in breakage at the notched portions of the fuse wires.

It is, accordingly, a general object of the present invention to provide an improved electric fuse construction in which the one or more fusible elements employed will not be subjected to the hazard of breakage during long operational life, in which the fuse elements are heated and cooled during normal operation.

A more specific object of the present invention is to provide an improved fuse construction in which the one or more fusible elements are provided by employing spaced cylindrically-shaped coil sections along the fusible element.

Another object of the invention is to provide an improved fusible element for a fuse in which the current-limiting advantages obtained by a notched fuse wire are obtained by employing spaced cylindrical coil sections, the improved fusible elements having substantially the same function as the notched fusible wires of the aforesaid patents, but avoiding notching the wire, which decreases its mechanical strength.

Further objects and advantages will readily become apparent upon reading the following specification, taken in connection with the drawing, in which:

FIG. 1 is a side elevational view, partially in vertical longitudinal section, of a fuse incorporating the principles of my invention and shown in the unblown condition;

FIG. 2 is a transverse sectional view taken along the line II—II of FIG. 1;

FIG. 3 is an enlarged fragmentary view of one form of the improved fusible element of the present invention;

FIG. 4 is a considerably enlarged, fragmentary, sectional view of the insulating rod utilized in connection

with the construction of FIG. 1, and showing the disposition of the improved fusible element of FIG. 3 within the grooves of the insualting rod; and,

FIGS. 5 and 6 illustrate, in enlarged manner, fuse element constructions employing a fuse strap instead of a round fuse wire.

Referring to the drawing, and more particularly to FIG. 1 thereof, the reference numeral 1 generally designates a tubular fuse holder of insulating material, such as fiber or a synthetic resin. The tubular fuse holder 1 is provided with terminal caps 2 and 3 adapted to be secured over the opposite ends of the tubular holder 1. Tubular caps 2 and 3 may be of any desired conducting material, such, for example, as copper or the like, and they are preferably secured into position by a pressed fit upon the ends of the fuse holder 1.

The fuse construction shown in FIG. 1 is similar to the fuse construction set forth in the foregoing patents and has desirable current-limiting functions. Generally, the fuse 1 comprises a fuse unit 4 including a rod 5 of an insulating material, which is capable of evolving an arc-extinguishing gas when in proximity to an electric arc, such, for example, as fiber or a synthetic resin. The rod 5 has a plurality of helically extending, or spiral slots or grooves 6 disposed upon its outside surface, and more clearly shown, in magnified fashion, in FIG. 4 of the drawing.

The longitudinally extending slots or grooves 6 are cut upon the outer surface of the rod 5 for the reception of one or more parallel disposed fusible elements 7, shown more clearly in FIG. 3 of the drawing. FIG. 4 shows the disposition of the fusible elements 7 within the slots 6 provided upon the external surface of the insulating rod 5.

The parallel disposed fusible elements 7 are adapted to be electrically connected at their ends with terminal discs 9, 10 in any desired manner, such as by soldering or the like. Insulating rod 5 has a plurality of spaced washer-shaped insulating barrier discs 11 provided thereon, for a purpose to be described, and the entire unit 4 is supported within fuse holder 1 in spaced relation to the tube 1 and to the end terminals 2 and 3.

As set forth in Patent 2,496,704, the opposite ends of the insulating rod 5 are provided with bores for receiving reduced extensions on the terminal discs 9 and 10. Electrically interconnecting the terminal disc 9 with the terminal cap 2 is a serially connected indicating means, which forms no part of my invention and, consequently, is not described. Reference may be had to Patent 2,496,704 for features of this indicating means. It may be stated that upon rupture, or blowing, of the fuse assembly the indicating means is actuated to permit the extension of an indicator disc 12, shown in FIG. 1.

The lower terminal disc 10 is directly electrically connected to the lower terminal cap 3. Disposed within the fuse holder 1 and about the fuse unit 4 is a mass of finely divided inert insulating material 14, such, for example, as sand. As mentioned previously, the sand 14 serves to absorb the energy created during rupture of the fuse unit 4.

As previously stated, the fuse unit 4, thus far described, is somewhat similar to the current-limiting structures described in the foregoing patents. Current limitation was accomplished in the structures of the foregoing patents by the employment of a notched silver fuse wire of special construction having a high temperature coefficient of resistance, which was initially chosen to be of substantially the same size as that required to carry the rated current without undue heating, and yet melt upon currents above the rated current. Such a notched silver fuse wire is disclosed in the foregoing patents, as well as in United

States Patent 2,667,549 issued January 26, 1954 to Harold H. Fahnoe and William A. Gaskill, and assigned to the assignee of the instant application.

It has been discovered that during some applications, such as for motor-starting duty, one of the difficulties encountered with the notched silver element was the tendency for the notched silver element to buckle and break at the notches due to normal expansion and contraction of the wire, as it is alternately heated and cooled. The present invention is concerned specifically with a novel type of fusible element adapted for current-limiting applications which lends itself readily to manufacture and in which reduced cross sections have not been obtained by notching or perforation. It is thus less subject to breaking mechanically.

With reference to FIG. 3, which shows in an enlarged fashion, one form of the fusible element 7 of the present application, it will be noted that the fusible element 7 includes a plurality of spaced, cylindrically-shaped coil sections or winding sections 16. The coil sections 16 may radiate from their inside and outside surfaces, and, consequently, serve the same function as the unnotched portions of the notched silver fuse wires described in the foregoing patents. Interspersed between the spaced coil sections 16 of the novel fusible element 7 are axial lengths of fuse wire 17, which are mechanically strong, not having been notched or otherwise mechanically deformed. These lengths 17 correspond to the notched portions of the prior-art notched silver fuse wires.

The method of winding the fusible wire 19 results in a single element which has sections of varying cross-section and thus of varying resistance. The cross-sectional area of the coils 16 is approximately equivalent to $\pi/4$ times the square of the outer diameter of the coil 16 minus the square of the inner diameter of the coil 16. This is appreciably greater than the cross-sectional area of the wire 19 itself.

Under normal load conditions, heat generated in the higher-resistance axial sections 17 is readily transferred to the lower resistance, and therefore cooler, coil sections 16. This carrying away of the heat from the short sections 17 permits the element 7 to operate at a higher load current than would be the case with a straight fuse element of the same minimum diameter.

When the fuse element 7 is subjected to a fault current with a high rate of rise, heat is generated in the axial sections 17 more rapidly than it can be carried away to the heavier, coiled sections 16. This results in the melting of the axial sections 17 and the establishment of a series of short arcs with the coiled sections 16 serving as terminals. A high, momentary arc voltage is generated, equivalent to the summation of all the series arcs and their associated anode-cathode voltage differentials. Should the current flow continue long enough, the heavier, coiled sections 16 will likewise melt and a second peak of arc voltage is generated. This second peak voltage is due to a single, confined arc which is of the same length as the initial fuse element 7.

The outside diameter of the coil sections 16, for example, may be approximately .102 inch or substantially ⅛ inch. Five to eight turns of the wire 19 may be employed with, for example, four coil sections 16 per inch of length of fusible element 7. The fusible wire 19 employed may be either silver or copper, or other suitable fuse-wire material. In one particular embodiment of the invention, 20 mil silver wire 19 was wound about a number 60 drill by hand, and 5 turns were employed for each coil section 16. The internal diameter of a coil section was, therefore, approximately 1/16 inch. The axial length L of the wire section 17 was approximately 1/16 of an inch. The axial length D of the coil section 16 was substantially ⅛ inch.

For different applications, the number of turns of wire for each coil section 16 will vary, the fuse-wire diameter will vary, and the inner and outer diameters of the coil sections 16 will vary depending upon the particular interrupting requirements, as will be obvious.

As shown in FIG. 4, the fusible element 7 is positioned within the grooves 6 of the insulating rod 5. Heat is rapidly dissipated from the coil sections 16 by the radiation from both the internal and external surfaces of the coil sections 16. Thus, the invention is concerned with a single conductor wire 19, which is wound in spaced cylinders 16 with intervening single axial sections 17 of the wire 19 therebetween. The construction offers the additional advantage of presenting a maximum radiation surface, as both the inside and the outside diameters of the cylinders 16 are exposed to the surrounding medium. This is important in a current-limiting fuse, as better cooling means a lesser number of conductors required for a given load-current rating, with a consequent lesser let-through current when the fuse melts under fault conditions.

Because the fuse elements 7 are in close proximity to the walls of the slots 6, it will be apparent that the arc formed upon interruption will cause the evolution of arc-extinguishing gas from the walls of the slot 6, and this gas will blast laterally through the arc to perform three functions, all of which act to increase the arc voltage and to extinguish the arc. First, the blast of arc-extinguishing gas acts to sweep metallic vapor out of the arc stream and out of the slots 6 into the inert material 14, in which the metal vapor becomes dispersed and condenses into separate particles insulated from each other, so that a high resistance path is maintained outside the slots 6. Secondly, the blast of arc-extinguishing gas also acts to supply un-ionized gas to the arc path to further increase the resistance of the arc path and to extinguish the arc at a current zero. A third function of the transverse gas blast is to cause the series arcs to be looped outwardly toward the filling material 14, thereby lengthening the arc path and, consequently, increasing the resistance thereof and the voltage drop across it. One function of the washers 11 on supporting rod 5 will now be apparent, as preventing escape of the arcs from the slots 6 and, consequently, from proximity with the gas-evolving material and from the restricting action of the narrow slot 6, and thus preventing the series arcs from restriking as a single arc outside the slots 6.

From the foregoing, it will be apparent that efficient current limitation of the first half cycle of the arcing current may be obtained with the structure disclosed, because the fusible elements 7 cause the establishment of a plurality of series arcs at the axial sections 17 on such high currents which it is desired to limit in a very short time, that is in a small fraction of a half cycle. As soon as the arc is established, it is subjected to all of the factors enumerated above to create an arc voltage high enough to prevent any further rise of the fault current.

When a fuse structure, such as that set out above, is applied on a repeated motor-starting duty operation, it will be apparent that because no mechanical notching, or otherwise deleterious mechanical operations are employed upon the fuse wire 19, the latter may be subjected to expansion and contraction as the wire is periodically heated and cooled without buckling and breaking at the axial sections 17. Thus, a mechanically strong and durable fusible element 7 is provided, which is suitable for long operational life in applications where alternate heating and cooling results.

FIGS. 5 and 6 illustrated modified type fuse-element constructions in which fuse strap material 21 may be employed instead of round fuse wire 19. Again coil sections 16′ and axial lengths 17′ are provided. The fuse strap material 21 may be either wound on an edge, as in FIG. 5 or on the broad side, as in FIG. 6.

Although there has been shown and described specific structures, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein

by those skilled in the art without departing from the spirit and scope of the invention.

I claim as my invention:

1. A current-limiting fuse including a pair of spaced terminals, conducting means electrically connecting the spaced terminals including one or more fusible conductors, and one of the fusible conductors having a portion with a plurality of spaced cylindrically-shaped uninsulated hollow coil sections per inch of length of said portion.

2. A current-limiting fuse including a pair of spaced terminals, conducting means electrically connecting the spaced terminals including one or more fusible conductors, an insulating rod forming a groove, one of the fusible conductors being disposed within the groove, and said one fusible conductor having a portion with a plurality of relatively small, spaced, cylindrically-shaped uninsulated hollow winding sections per inch of length of said portion.

3. A current-limiting fuse including a pair of spaced terminals, conducting means electrically connecting the spaced terminals including one or more fusible conductors, one of the fusible conductors having a portion with a plurality of spaced cylindrically-shaped hollow coil sections per inch of length of said portion, and finely divided inert insulating material disposed in proximity to the conducting means to assist in arc extinction, said coil sections having no solid dielectric material attached thereto.

4. The combination in a current-limiting fusible device of a pair of spaced terminals, one or more fusible elements connected between the spaced terminals and adapted to fuse upon fault conditions, and the one or more fusible elements including a fuse wire having a portion with a plurality of spaced uninsulated hollow coil sections per inch of length of said portion.

5. The combination in a current-limiting fusible device of a pair of spaced terminals, one or more fusible elements connected between the spaced terminals and adapted to fuse upon fault conditions, a grooved gas-evolving insulating support rod for supporting at least one of said fusible elements within a groove, and the one or more fusible elements including a fuse wire having a portion with a plurality of spaced uninsulated hollow coil sections per inch of length of said portion.

6. A current-limiting fusible device including a fuse holder of insulating material having spaced terminals thereon, current-limiting circuit-interrupting means connected between said terminals including one or more fusible elements, a rod of insulating material having one or more grooves provided thereon, the one or more fusible elements being disposed within the one or more grooves, and the fusible elements including a multiplicity of closely-spaced, cylindrically-shaped uninsulated hollow winding sections so that at least a plurality of winding sections exist per inch of length.

7. A current-limiting fusible device including a fuse holder of insulating material having spaced terminals thereon, current-limiting circuit-interrupting means connected between said terminals including one or more fusible elements, a rod of insulating material having one or more grooves provided thereon, the one or more fusible elements being disposed within the one or more grooves, the fusible elements including a multiplicity of closely-shaped, cylindrically-shaped hollow winding sections so that at least a plurality of winding sections exist per inch of length, and finely divided inert insulating material disposed about said insulating rod to assist in arc extinction said winding sections having no solid dielectric material attached thereto.

8. A fuse including a pair of spaced terminals, conducting means electrically connecting the spaced terminals including one or more fusible conductors, one of the fusible conductors having a portion with a plurality of spaced cylindrically-shaped uninsulated hollow coil sections per inch of length of said portion, and axial lengths of the fusible conductor connecting the spaced cylindrically-shaped coil sections.

9. A fuse including a pair of spaced terminals, conducting means electrically connecting the spaced terminals including one or more fusible conductors, an insulating rod forming a groove, one of the fusible conductors being disposed within the groove, said one fusible conductor having a portion with a plurality of relatively small, speed, cylindrically-shaped uninsulated hollow winding sections per inch of length of said portion, and axial lengths of the fusible conductor connecting the spaced cylindrically-shaped winding sections.

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