Dec. 1, 1959 P. G. JOHNSTON 2,915,609

FUSIBLE PROTECTIVE DEVICES

Filed Oct. 23, 1957

Fig. 7.

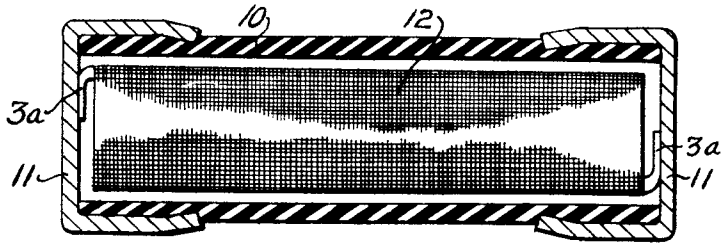


Fig. 1.

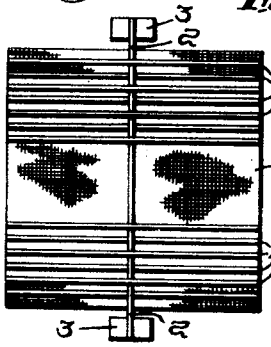


Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.

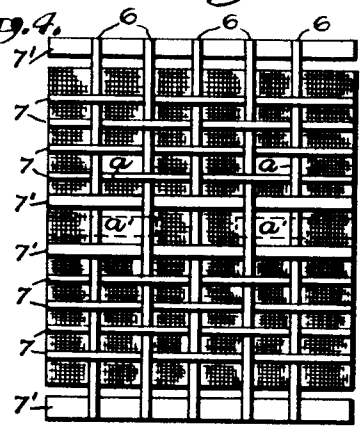
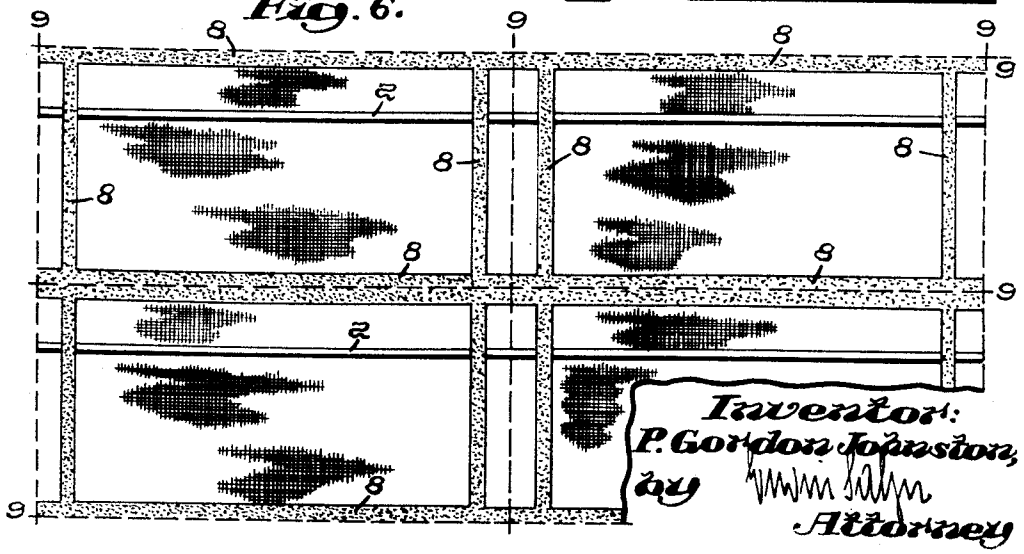


Fig. 6.



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FUSIBLE PROTECTIVE DEVICES

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Application October 23, 1957, Serial No. 691,852
4 Claims. (Cl. 200—135)

This invention relates to fusible protective devices, i.e. to electric fuses, and more particularly to current-limiting fuses. Current-limiting fuses are fuses which operate so fast as to preclude the peak of the let-through current from ever reaching the peak of the available fault current.

It is one object of this invention to provide improved electric fuses for relatively low current ratings.

The fusible element of electric fuses for low current ratings—one amp. or a fraction thereof—is formed by a thin very fragile wire.

It is one object of this invention to provide electric fuses having fusible elements in the form of thin very fragile wires which are not likely to be damaged in spite of the fragility thereof.

Fusible elements in electric fuses for low current ratings are often air immersed, i.e. a pulverulent arc-quenching filler is dispensed with. Such fuses do not lend themselves to application in circuits whose circuit voltage is relatively high. Fuses having no pulverulent arc-quenching filler, even if capable of successfully interrupting circuits having a relatively high circuit voltage—say more than 100 volts—are generally subject to the limitation of permitting a relatively large amount of energy to flow in the faulted circuit before complete interruption thereof.

It is, therefore, another object of this invention to provide electric fuses which do not comprise a pulverulent arc-quenching filler, and which lend themselves to applications in circuits having higher circuit voltages than the circuits in which comparable fillerless fuses could heretofore be used and which fuses drastically limit the amounts of energy supplied after fault inception from the energy source to the faulted circuit.

Another object of the invention is to provide improved fuses for the protection of small apparatus, i.e. so-called instrument fuses, of improved design.

Fuses are either fitted with fusible elements in wire form or in ribbon form. Both types of elements have different time-current-curves, or fusing characteristics, and differ also in other respects, e.g. in respect to the rate of de-ionization of the arc formed incident to blowing of the fuse.

It is another object of the invention to provide a family of fuses having time-current-curves, and other characteristics, intermediate those of fuses with fusible elements in wire form and those with fusible elements in ribbon form.

Current-limiting fuses for relatively high current ratings call for fusible elements in ribbon-form. Such elements must be provided with one or more points of reduced cross-sectional area in order to obtain the required degree of current-limitation, and to produce the required arc voltage. The presence of these points of reduced cross-sectional area weaken such fuse links considerably, and make the handling of fuses which have such fuse links relatively difficult.

It is, therefore, another object of this invention to provide fuses having fuse links comprising many or all of the essential operational features of ribbon-type fuse links with one or more points of reduced cross-sectional area, which fuses are not subject to the limitations inherent in fuses with such fuse links, and which fuses are relatively rugged and not likely to be damaged during the manufacturing process, and thereafter.

The most critical ribbon-type fuse links are those wherein provision of a point of reduced cross-sectional area results in almost complete severance of the link. Such fuse links having a very drastic local reduction of cross-sectional area are needed for fuses calling for a very drastic reduction of the peaks of the let-through currents.

It is another object of the invention to provide electric fuses having novel fusible means whose operational characteristics are more or less equivalent to those of ribbon links wherein the point of reduced cross-sectional area is so small as to approximate a point heat source, and which novel fusible means are rugged and not likely to break accidentally even if subjected to considerable abuse.

Another object of the invention is to provide fuses wherein the fusible element and the arc energy absorbing means are formed by a structural unit or subassembly.

Another object of the invention is to provide improved fuse structures which lend themselves well to application in circuits whose circuit voltage exceeds 600 volts and may be as large as many kilovolts.

Further objects, advantages and features of this invention will become apparent as the following description proceeds, and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to, and forming part of, this specification.

For a better understanding of the invention reference may be had to the accompanying drawings illustrating the invention wherein

Fig. 1 is a diagrammatic elevational view of the basic parts of a fuse embodying this invention having operational characteristics intermediate those of a fusible wire fuse and those of a fusible ribbon fuse;

Figs. 2 and 3 show in elevation a comparable fusible wire and a comparable fusible ribbon;

Fig. 4 is an elevational view of a prior art ribbon-type fuse link having a point of reduced cross-sectional area;

Fig. 5 is an elevational view of the basic parts of a fuse embodying the invention and having a time-current-curve of the same or a similar nature as the ribbon-type fuse link of Fig. 4;

Fig. 6 is a front view of a composite material which may be used for manufacturing fuses embodying the invention; and

Fig. 7 is in part an elevational view and in part a longitudinal section of a low-voltage fuse embodying the invention.

Referring now to Fig. 1, numeral 1 has been applied to indicate a piece of cloth, or woven fabric, made of glass fibers, or of fibers of a similar silicious material, such as quartz, having a very high latent heat of fusion. Silver wire 2 is interwoven in glass cloth 1, and its two ends projecting beyond cloth 1 are conductively connected to a pair of terminals 3. Terminals 3 are made of a relatively rugged sheet metal, e.g. tin plated sheet copper. The ends of silver wire 2 may either be spot-welded or soldered to terminal plates 3. Glass cloth 1 may be folded together to form a package or rolled to form a roll. For instance, one portion of glass cloth 1 is folded forwardly, and one portion of glass cloth 1 is folded backwardly, as clearly shown in Fig. 2, so that the middle portion of the glass cloth 1 with the woven in silver wire 2 is sandwiched between two outer portions, or layers, of glass cloth.

If desired, the folded or rolled fabric structure may be inserted into a tubular or other casing. As an alternative, it may be impregnated with a suitable plastic.

Wire 2 may be so thin as to make manual handling thereof extremely hazardous, or even impossible, but when handled jointly with the cloth support 1, i.e. the

cloth base into which it is woven, handling of the wire 2 is not problematical any longer, and the danger of injury to the wire is virtually eliminated.

Terminal elements or terminal tabs 3 serve the purpose of inserting the fusible wire 2 into an electric circuit. The metal vapors formed upon fusion of the wire condense on the glass grid formed by the constituent threads or fibers of glass cloth 1. At the occurrence of relatively severe faults all the glass yarn of which cloth 1 is made fuses under the heat of the arc and forms upon subsequent resolidification a solid mass of silver silicates, or fulgurite. Where the glass grid is applied in circuits dissipating sufficient energy incident to interruption thereof to cause complete fusion of the grid, the grid ought to be enclosed in a tubular casing (as shown in Fig. 7), and it may also be necessary or desirable to surround the glass grid by a pulverulent arc-quenching filler, such as quartz sand. Where the interrupting conditions are not severe the pulverulent arc-quenching filler and even the tubular casing may be dispensed with, i.e. in such instances the deionizing action of the glass fiber grid is sufficient to achieve safe interruption of the faulted circuit.

Referring now again to Fig. 1 silver wire 2 forms an integral part of the warp threads of the sheet of cloth 1. The weft comprises glass threads and a relatively large number of substantially filamentary metal conductors 4. The total cross-sectional area of weft conductors 4 exceeds by far the cross-sectional area of silver wire 2. Silver wire 2 is the only conductor which carries current from the upper terminal 3 to the lower terminal 3. The weft conductors 4 form non-current-carrying cooling fins for the current-carrying heat-generating conductor 1, thus greatly increasing the current-carrying capacity of conductor 1. The area around the middle of conductor 1 has no cooling-fin-forming weft conductors. This is the area where conductor 1 is hottest, and where arc initiation occurs upon fusion of conductor 1. In this area the warp and the weft consist of glass fibers only and, therefore, this area has a relatively high de-ionizing and cooling action.

The fuse structure shown in Fig. 1 has a time-current-curve which may be considered to be an intermediate of that of the fusible wire shown in Fig. 2 and that of the ribbon fuse link shown in Fig. 3. Under comparable conditions the structure of Fig. 1 generates heat in the same way as the fusible wire of Fig. 2, but the former has a considerably larger heat dissipating ability and, therefore, a considerably higher current-carrying capacity. Under severe fault conditions the heat generation in wire 2 is so rapid that it reaches fusing temperature before any significant heat dissipation occurs by the cooling-fin-forming filamentary weft conductors.

Referring now to Fig. 4, this figure shows a conventional ribbon-type link having a point of reduced cross-sectional area formed by a circular perforation 5. The larger the diameter of perforation 5, the smaller the let-through current passed by such a fuse link, and the more fragile such a link. Where perforation 5 is large because it is desired to achieve a small current-limiting ratio, i.e. a small ratio of the smallest current at which current limitation occurs to the rated current of the fuse, the fuse link may become critically fragile and extremely hard to handle.

The structure of Fig. 5 has a time-current-curve and other operating characteristics similar to the ribbon-type fuse link shown in Fig. 4 but is not fragile, and of a rather rugged nature. The structure shown in Fig. 5 comprises a piece of glass cloth 1 having metallic warp and metallic weft filaments. The metallic warp filaments are indicated by the reference character 6 and the metallic weft filaments are indicated by the reference characters 7 and 7'. The weft filaments 7 are relatively narrow and thin and the weft filaments 7' are relatively wide and thick. The main function of weft filaments 7 is to dissipate the heat generated in the warp filaments 6. Heat is transferred from each warp filament 6 to each weft filament 7 in contact therewith. The contact between both may be electrically relatively poor, yet the average contact between filaments 6 and 7 is sufficiently good to cause a substantial transfer of heat from the former to the latter. Each weft filament 7' is conductively connected to each of the warp filaments 6 at the points where filaments 6, 7' are in physical engagement with each other. This may be achieved by spot welding. As an alternative, the filaments to be conductively interconnected may be tin plated before being woven into the cloth 1, and the cloth with the tin plated filaments in it may be subjected to the action of heat and pressure to cause formation of solder bonds on all cross-over points of filaments 6 and 7'. The relatively wide axially outer filaments 7' form terminals for connecting the metallic weft filaments 6 of the composite glass-fiber and metal filament structure into an electric circuit. The composite fabric structure shown in Fig. 5 is fashioned into a fuse link having a point of very small cross-sectional area by cutting, or punching, two lateral incisions into it. These incisions have been indicated by a pair of dashed lines to which the reference characters *a'*, *a* have been applied. Incisions *a'*, *a* sever four of the five metallic warp filaments 6, leaving at one point but one current-carrying warp filament 6, i.e. the warp filament situated in the center of the composite metal and glass fiber fabric. The fabric has substantial mechanical strength in spite of the fact that but one single metallic warp filament 6 remains unsevered, this being due to the mechanical strength imparted to the fabric by the glass cloth remaining to both sides of the non-severed metallic warp filament 6.

It will be apparent that Fig. 5 depicts the most difficult instance wherein but one single metallic warp filament remains unsevered. It is possible to achieve a substantial local reduction of cross-sectional conductor area by severing less than all metallic warp filaments 6 in the composite metal and glass filament fabric. It will also be apparent that there are many ways, in addition to lateral incisions, for severing some, i.e. less than all, of the metallic warp filaments 6 as, for instance, providing a central punching in the fabric severing the three inner metallic warp filaments 6 and not affecting the two outer metallic warp filaments 6. The metallic warp filaments 6 which are severed by incisions *a'*, *a* carry current from the axially outer terminal metallic weft filaments 7' to the axially inner metallic weft filaments 7'. This greatly increases the current-carrying capacity of a composite fabric of the type shown in Fig. 5 relative to the current-carrying capacity of a composite fabric of the type shown in Fig. 1.

Fusible protective devices of the type shown in Figs. 1 and 5 may be made from a composite metal filament and glass-fiber fabric in tape form. Fraying of edge portions may be prevented by coating edge portions of the fabric with a suitable plastic substance, i.e. a substance which evolves gases under the heat of the arc favoring the arc-quenching process rather than tending to impede arc extinction. There are many plastics known to have the required arc-quenching properties and, therefore, there is no need of being specific in this respect. The edge binding plastic ought to be carbon-poor and substantially non-tracking.

Fig. 10 shows an alternative to link-forming fabric in tape form, i.e. a glass-cloth which is subdivided into rectangles by rolled on plastic strips 8. The dashed lines 9 indicate how this material is to be cut to form square patches of which each includes a metallic fusible warp conductor 2 and additional conductors as explained in connection with Figs. 1 and 5 (not shown in Fig. 6). It will be apparent that the horizontal cuts 9 extend through the center lines of the horizontal strips 8, whereas the vertical cuts 9 extend along strips of glass fiber cloth formed between pairs of spaced vertical strips 8. This precludes fraying along the horizontal cuts, but permits

to remove some of the glass fibers along the vertical cuts to expose the ends of wires 2 which must be conductively connected to some terminal element as, for instance, the terminal elements 3 shown in Fig. 1.

Referring now to Fig. 7, the structure shown therein comprises a tubular casing 10 made of an insulating material such as, for instance, vulcanized fiber, closed on both ends thereof by terminal elements in the form of caps or ferrules 11. The axially inner ends of caps or ferrules 11 are crimped to form a mechanically strong bond with casing 10. Casing 10 houses a roll 12 formed of an integral metal filament and glass fiber fabric such as described in connection with the preceding figures. Roll 12 has tab-like terminal elements 3*a*—similar to the terminal elements 3 shown in Figs. 1 to 5—which are soldered to caps or ferrules 11. This may be achieved by tinning the terminals 3*a*, and heating the ferrules 11 and the terminals 3*a* by induction heating subsequent to mounting the caps or ferrules 11 on casing 10.

While I prefer to use webs or fabrics of woven glass fibers, the constituent glass fibers of the web or fabric could be interlocked by means other than weaving, e.g. by knitting. It is, however, important to apply the glass fibers in interlocked fabric form to produce fusible conductor-supporting webs or fabrics of sufficient strength. The filamentary metallic conductors should preferably be made integral parts of the composite fabric by weaving, but other methods of securing the metallic fibers to the supporting glass fibers will do as long as such other method results in an interlocking relation between the metallic filaments and the glass fibers in a fashion similar to that obtained by weaving.

It is also possible to substitute for glass fibers other fibers of a silicious inorganic insulating material having arc-quenching properties similar to those of quartz. Quartz sand or silica are arc-quenching materials having an arc energy absorbing ability of about 2 kw.-sec./gram, and the silicious fibers to be used for composite metal filament and non-metallic fiber fabrics ought to have an energy absorbing ability of the same order.

The behavior of the glass or other silicious fibers under arcing conditions depends upon the amount of arc energy released. Metal vapors may be condensed on the grid of woven glass fibers or like fibers. Loose fibers which project into the arc path are melted to glass beads, or glass-like beads. These phenomena are typical for the interruption of relatively small currents involving relatively little arc energy. If the intensity of the current under interruption and the arc energy are increased, the glass filament structure is completely melted and turned into a fulgurite.

It appears from the foregoing that the fabric support for the fusible element is an energy absorber of the first order, highly effective because of its inherently high energy absorbing capacity coupled with its immediate vicinity to the fusible element. The energy absorbing capacity of the fabric support for the fusible element is sufficient up to certain limit values of fault current and circuit voltage and other factors determining the severity of the particular interrupting process to be effected by the protective device under consideration. Where these limit values are exceeded it becomes necessary to supplement the arc energy absorbing capacity of the composite fabric by addition of a pulverulent arc-quenching filter.

While I prefer to use silicious inorganic fibrous materials for making the fabrics which support the fusible elements, the fabrics might be made of other fibrous relatively heat resistant materials. Silicone fabrics could be used for supporting the fusible elements if the fusing point of the latter were less than the temperature which the former can withstand without deterioration. A tin coated silver link fuses and deteriorates by corrosion at temperatures below the danger temperatures to silicone fabrics and, therefore, silicone fabrics can be used as supports for fuse elements in the form of tinned silver wires. Nevertheless, fabrics of silicious inorganic fibers such as glass fibers or quartz fibers are preferable to fabrics of silicone fibers because the former have a high energy absorbing ability which the latter do not have, and because the latter are subject to some tracking.

Having disclosed several preferred embodiments of the invention it is desired that the same be not limited to the particular structures 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 the 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. A fusible protective device comprising a pair of spaced terminal elements, a fabric of mutually interlocking fibers of an inorganic silicious material, at least one metallic substantially filamentary conductor interwoven in and supported by said fabric, said conductor conductively interconnecting said pair of terminal elements, and a plurality of substantially transverse metallic substantially filamentary conductors forming an integral part of said fabric adapted to effect increased heat dissipation from said one conductor when said one conductor is carrying current.

2. A fusible protective device comprising a pair of spaced terminal elements, a fabric of mutually interlocking fibers of an inorganic silicious material, said fabric including a plurality of current-carrying conductors extending across and conductively interconnecting said pair of terminal elements, and said fabric further including a plurality of substantially transverse metallic conductors for increased heat dissipation from said plurality of current-carrying conductors.

3. A fusible protective device comprising a ribbon formed of a fabric of mutually interlocking fibers of an inorganic silicious material; at least one metallic substantially filamentary conductor arranged in the center of and supported by said ribbon and arranged in interlocking relation with the constituent fibers thereof; a plurality of metallic substantially filamentary conductors oriented substantially transversely to said one conductor and supported by said ribbon and arranged in interlocking relation with the constituent fibers thereof; said one conductor being adapted to carry an electric current and said plurality of conductors being adapted to form a pair of lateral cooling fins for dissipating the heat generated in said one conductor.

4. A fusible protective device comprising a piece of fabric of mutually interlocking fibers of an inorganic silicious material; a first system of metallic substantially filamentary conductors supported by said fabric and arranged in interlocking relation with the constituent fibers thereof; a second system of metallic substantially filamentary conductors oriented substantially transversely to said first system of conductors supported by said fabric and arranged in interlocking relation with the constituent fibers thereof; means for conductively interconnecting the constituent conductors of said first system and the constituent conductors of said second system at the points of cross-over thereof; and a part of the constituent conductors of said first system being severed at a point between the ends thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

1,054,068	Williams	Feb. 25, 1913
1,508,839	Dreyer	Sept. 16, 1924
2,759,092	Fortin	Aug. 14, 1956

FOREIGN PATENTS

547,160	Great Britain	Aug. 17, 1942

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,915,609

December 1, 1959

P. Gordon Johnston

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 63, strike out ", as clearly shown in Fig. 2,"; column 4, line 64, for "Fig. 10" read -- Fig. 6 --; line 67, for "square" read -- rectangular --; column 5, line 59, before "up" insert a comma; line 66, for "filter" read -- filler --.

Signed and sealed this 24th day of May 1960.

(SEAL)
Attest:
KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE

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