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2,914,636

MINIATURIZED HIGH CURRENT-CARRYING CAPACITY CURRENT-LIMITING FUSES WITH BUILT-IN INDICATING PLUNGERS

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This invention relates to miniaturized high current-carrying capacity current-limiting fuses, particularly fuses adapted for the protection of individual cells of germanium rectifiers and of silicon rectifiers.

To achieve the degree of compactness required for such applications, i.e. for subminiature power fuses, the ratio of the kva. rating of the fuse to the internal volume of the fuse must be very large. The required degree of compactness can only be achieved by providing such fuses with fusible elements in the form of wide, extremely short ribbons. The arc formed incident to blowing of the fuse can be quenched before the fusible element is entirely consumed if the latter is made of silver whose vapors are a bad conductor of electricity at the temperature range around the boiling point of silver, and if the fusible element is immersed in a pulverulent arc-quenching filler, such as quartz sand, whose energy absorbing capacity is very high.

Heretofore it has not been possible to provide subminiature power fuses of the kind applied for the protection of individual cells of germanium rectifiers or silicon rectifiers with built-in blown fuse indicating plungers and it is, therefore, one object of this invention to provide current-limiting fuses of the afore-mentioned character which comprise built-in indicating plungers.

Indicating plungers are normally held in position against the bias of a spring by a fusible element in wire form, generally made of steel, to obtain the high degree of tensile strength required for the purpose. The fusible element formed by the steel wire shunts the fusible silver ribbon which normally carries substantially the entire current of the circuit controlled by the fuse. The resistance of the steel wire is so high that it carries hardly any current as long as the fusible silver ribbon is intact. After destruction by fusion and arcing of the current path formed by the silver ribbon, the voltage prevailing across the steel wire becomes sufficiently high to cause a current to flow capable of rapidly fusing the steel wire. The voltage gradient along the arc formed by fusion and back-burning of the steel wire tends to be relatively small, the vapors of steel being a relatively good conductor of electricity at the temperature around the boiling point of steel. Because the voltage gradient along an arc resulting from vaporization of steel wire, even if relatively thin, tends to be relatively low, the required minimum length for the fusible indicating plunger restraining wire of steel may exceed the maximum length permissible for the current-carrying ribbon fuse link of silver, i.e. the length not to be exceeded if the required current-carrying capacity is to be maintained.

The prior art method to cope with substantially different requirements in regard to the length of the current-carrying fusible element and in regard to the length of the fusible restraining wire for a blown fuse indicating plunger consists in housing the former and the latter in two separate casings of which one may be mounted on the other such as shown, for instance, in Figs. 1 and 2

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of United States Patent 2,794,095 to Frederick J. Kozacka, May 28, 1957, Striker Pin Structures. This arrangement is, however, too bulky for subminiature power fuses such as required for the protection of individual germanium and silicon rectifier cells.

It is, therefore, one object of this invention to provide subminiature current-limiting power fuses sufficiently compact to be used for the protection of individual germanium and silicon rectifier cells which fuses have a built-in rather than an additional external indicating plunger.

Another object of the invention is to provide a subminiature power fuse having a built-in indicating plunger wherein the abutment means precluding the indicating plunger from coming off the fuse structure upon fusion of the restraining wire for the plunger are arranged inside the extremely compact casing of the fuse in such a way as not to be impaired by arcing.

Another object of the invention is to provide subminiature current-limiting power fuses having indicating plungers and restraining wires therefore inserted into the circuit without resorting to solder joints.

Other objects and advantages of the invention will, in part, be obvious and in part appear hereinafter.

For a more complete understanding of the invention reference may be had to the following detailed description thereof taken in connection with the accompanying drawings wherein

Fig. 1 is substantially a longitudinal section along a fuse embodying this invention, the section being taken along 1—1 of Fig. 2;

Fig. 2 is a section along 2—2 of Fig. 1;

Fig. 3 is a top plan view of the structure shown in Fig. 1 seen in the direction of the arrow R;

Fig. 4 shows a portion of the structure of Fig. 1 on a larger scale; and

Fig. 5 is an isometric view of the structure of Figs. 1 to 3 upon blowing of the fuse showing the indicating parts in their indicating position.

Referring now to the drawing, numeral 1 has been applied to indicate a tubular synthetic-resin-glass-fibercloth laminate casing. The binder resin for the laminate may either be a melamin resin, a silicone resin, or some other synthetic resin suitable for the purpose in hand. A pair of metal plugs 2 is press-fitted into casing 1, closing both ends of the same. Each plug 2 comprises a blade contact 3 forming an integral part thereof. Each blade contact 3 extends axially outwardly from the plug 2 of which it forms an integral part and each blade contact 3 subdivides the axially outer surface of each plug 2 into two contiguous substantially semi-circular areas 4. The axially inner surfaces of plugs 2 are each provided with two grooves 5 extending across the axially inner surfaces of the plugs 2 immediately adjacent the center thereof. In other words, the length of grooves 5 is almost equal to the diameter of plugs 2 and the ribbon-type fusible elements 6 inserted into grooves 5 have virtually the largest possible width which can be imparted to a flat fusible element housed in casing 1. Fusible elements 6 are each formed by a strip of sheet silver having V-shaped lateral incisions 7 defining a neck 8 of short length and width forming virtually a point heat source when fusible elements 6 are carrying current. Fusible elements 6 are made of silver because silver has the most favorable ratio of conductivity and fusing energy for current limitation. Fusible elements 6 are secured in grooves 5 by solder joints (not shown) to minimize the electric resistance between elements 6 and plugs 2.

Each plug 2 defines one of a pair of coaxial bores 9 extending in a direction longitudinally of casing 1. The distance between the axis of the casing 1 and the fusible

elements 6 has been marked "a" and the distance between the axis of casing 1 and bores 9 has been marked "b." It is apparent that the latter distance is much larger than the former distance. This combines the feature of greatest possible link width, or fusible element width, with that of a desirable location of the blown fuse indicator mechanism as will be more apparent from what follows below.

Each bore 9 extends from one of the center regions of one of the semi-circular areas 4 into the inside of casing 1. Resilient metal caps 10 and 11 are inserted into bores 9, and firmly held therein by friction. Cap 10 is recessed in one of the semi-circular areas 4 in the center region thereof and houses a helical biasing spring 12, an indicating plunger 13 and an indicating cap 15 of metal. Plunger 13 and cap 15 are biased axially outwardly by spring 12 and arranged in coaxial relation with respect to cap 10 and spring 12. The axially inner end of plunger 13 projects through the axially inner end of cap 10 into one of the bores 9 in one of the plugs 2. The axially inner end of plunger 13 is flattened and perforated, and a fusible plunger restraining wire 14 of steel is threaded through the perforation in plunger 13. Wire 14 extends through the bore 9 immediately adjacent cap 10 and through casing 1 and through the bore 9 immediately adjacent to cap 11.

Cap 11 clamps the two ends of wire 14 against the surface of bore 9 into which cap 11 is press-fitted, thus establishing a good electrical pressure contact between wire 14 and plug 2 remote from the indicating plunger 13. It will be apparent that the circuit of the steel wire 14 shunts the circuit of the fusible silver elements 6 whose conductivity is high, and that this shunt circuit is established by reliable pressure contacts only, i.e. without resorting to soldered joints or connections. Provision of the additional indicating cap 15 forming an integral part of plunger 13 is optional. Its presence is desirable because it increases, when brightly colored, the ease of checking whether or not a given fuse has blown. As a general rule blade contacts 3 will be silver plated and form a contrary background for colored indicating cap 15, from whatever angle cap 15 should be viewed.

A filler 16 of quartz sand fills the main space inside of casing 1 as well as the spaces inside of bores 9 of plugs 2.

Upon fusion of links or fusible elements 6 as a result of an excess current, an arc is kindled which takes the place of fusible element 6. This arc is rapidly quenched by the action of the pulverulent arc-quenching filler 16. The increasing voltage drop across the arc causes an increase of current flow through steel wire 14, as a result of which the latter fuses almost instantaneously. The excess length of wire 14 over links 6 is sufficient to generate the arc voltage required to safely extinguish the arc resulting from fusion of wire 14. The task of extinguishing this arc is particularly onerous not only because this arc is one resulting from the vaporization of steel, but also because the space wherein this arc is formed has been pre-heated by the previous power arc resulting from fusion of fusible elements 6. The body 16 of quartz sand in which the axially inner end of plunger 13 is immersed is a sufficiently reliable and effective arc quencher to preclude vaporization of this end of the plunger which would be dangerous since it would entail formation of a critical amount of steel vapor.

Having disclosed a preferred embodiment of my invention it is desired that the same not be 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. In a subminiature current-limiting power fuse the combination of a tubular casing of insulating material circular in cross-section, a pair of metal plugs closing both ends of said casing, groove means extending across the axially inner surfaces of said pair of plugs immediately adjacent to the center thereof, each of said pair of plugs defining one of a pair of coaxial bores extending in a direction longitudinally of said casing and being spaced a greater distance from the axis thereof than said groove means, ribbon link means inserted into said groove means conductively interconnecting said pair of plugs, a first resilient metal cap inserted into one of said pair of bores at the axially outer end thereof, an indicator plunger and an indicator plunger biasing spring housed in said first cap, a fusible restraining wire attached to said plunger extending through said one of said pair of bores and through said casing into the other of said pair of bores, a second resilient metal cap inserted into said other of said pair of bores and clamping said fusible restraining wire against said other of said pair of bores, and a body of pulverulent filler inside said casing and inside said pair of bores.

2. In a subminiature current-limiting power fuse the combination of a tubular casing of insulating material circular in cross-section, a pair of metal plugs closing both ends of said casing, a pair of blade contacts each forming an integral part of one of said pair of plugs each subdividing the axially outer surface of one of said pair of plugs into two contiguous substantially semi-circular areas, each of said pair of plugs defining one of a pair of coaxial bores each extending from one of said semi-circular areas into the inside of said casing, ribbon link means arranged parallel to the plane defined by said pair of blade contacts conductively interconnecting said pair of plugs, a resilient metal cap inserted into one of said pair of bores at the axially outer end thereof, an indicator plunger, an indicator plunger biasing spring and an indicator cap housed in said metal cap, a plunger abutment forming an integral part of said plunger arranged outside of said metal cap inside said one of said pair of bores, a fusible wire attached to said plunger abutment extending through said one of said pair of bores and through said casing into the other of said pair of bores, means inserted into said other of said pair of bores for clamping said fusible wire in position, and a body of pulverulent filler inside said casing and inside said pair of bores.

3. In a subminiature current-limiting fuse the combination of a tubular synthetic-resin-fiber-glass-cloth laminate casing circular in cross-section, a pair of metal plugs each press-fitted into one end of said casing, a pair of blade contacts each forming an integral part of one of said pair of plugs and each subdividing the axially outer surface of one of said pair of plugs into two contiguous substantially semi-circular areas, a first relatively short relatively wide fusible means formed by a strip of sheet silver arranged inside said casing parallel to the plane defined by said pair of blade contacts and conductively interconnecting the axially inner surfaces of said pair of plugs, a second relatively long relatively thin fusible means formed by a wire of steel arranged inside said casing and conductively secured with the ends thereof to points of said pairs of plugs immediately adjacent to said semi-circular areas, a first relatively short body of quartz sand enveloping said first fusible means, a second relatively long body of quartz sand enveloping said second fusible means, a cap recessed adjacent the center of one of said semi-circular areas, a helical biasing spring arranged inside of said cap, and an indicating plunger under the bias of said spring arranged in coaxial relation inside said spring and said cap and projecting through the bottom end of said cap into said second body of quartz sand, and said plunger having a flattened perforated end through which said second fusible means is threaded.

4. In a subminiature current-limiting fuse the combination of a tubular synthetic-resin-fiber-glass-cloth laminate

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casing circular in cross-section, a pair of metal plugs each press-fitted into one end of said casing, a pair of blade contacts each forming an integral part of one of said pair of plugs and each subdividing the axially outer surface of one of said pair of plugs into two contiguous substantially semi-circular areas, each of said pair of plugs defining one of a pair of coaxial bores each extending from one of said semi-circular areas into said casing, a pair of relatively short ribbon fusible elements of silver arranged in planes parallel to the plane defined by said pair of blade contacts each having one single point of reduced cross-sectional area between the ends thereof, a relatively long wire fusible element of steel extending with the ends thereof into said pair of coaxial bores, a first metal cap inserted into one of said pair of bores at the axially outer end thereof, an indicator plunger, and indicator plunger biasing spring and a second metal cap

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housed in said first metal cap, said plunger projecting through said first metal cap into one of said pair of bores and having a flattened perforated end situated in said one of said pair of bores, said wire fusible element being threaded through said perforated end of said plunger, and a body of quartz sand inside of said casing and inside of said pair of bores.

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