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FUSE HAVING AN AUXILIARY ARC-TRANSFER ELECTRODE

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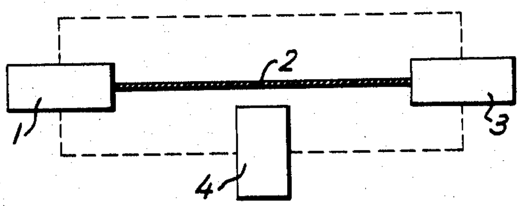
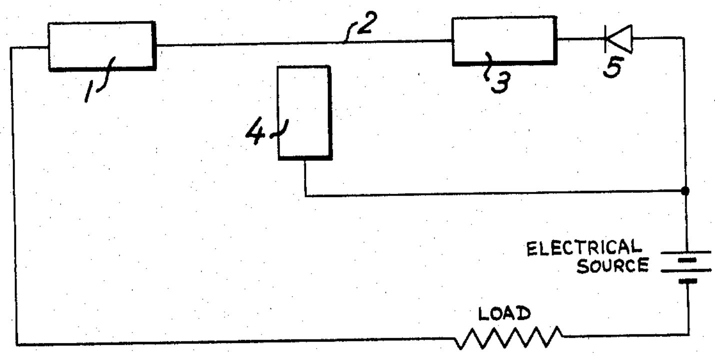


Fig. 1

Fig. 2



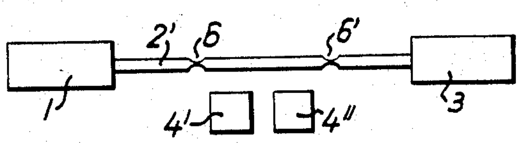


Fig. 3

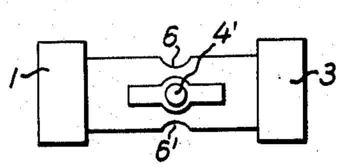


Fig. 4

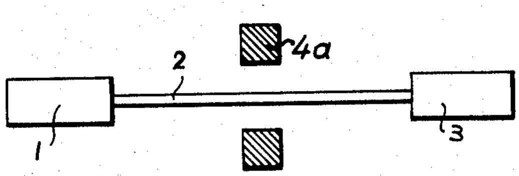


Fig. 5

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FUSE HAVING AN AUXILIARY ARC-TRANSFER ELECTRODE

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The present invention relates generally to the fuse art, and, more particularly, to electrically protective devices with very rapid response times.

The use of highly sensitive electrical appliances and components in technical fields often requires that precautions be taken to protect the circuitry against current overloads which are not permitted. Semiconductor elements in particular are sensitive to such overloads because of the small thermal capacity of the semiconductor material and therefore such elements need protective devices which respond very quickly. Quickly responsive protective devices have been previously known, such as, for example, exceedingly fast safety fuses. However, known safety fuses are subject to the disadvantage that after the fuse conductor has responded and has fused or melted, an electric arc occurs between the residual portions of the fuse conductor. This permits the conduction of current for a period of time until the energy stored by the inductance of the circuit at the beginning of the arc, has been transformed into heat in the real resistance of the circuit and in the arc itself. Furthermore, the source of operating voltage provides energy to the electric circuit even while this process is being carried out and thus prolongs the duration of current flow while the arc is in existence.

With high excess current values and the consequently short fusing or melting times of the fuse conductor of the fuse, the period of time during which the arc continues to conduct the excess current may be as long as the duration of the fusing time or even a multiple thereof. The so-called fuse integral $\int i^2dt$ which is proportional to the heat developed governs the fusing of the fuse conductor. This fuse integral is nearly constant in the region of high excess currents and short fusing time. However, the total value of the integral over the square of the excess current which is allowed to pass through the fuse increases considerably with higher excess currents because of the current conducting time of the fuse which is prolonged by the arc. Since the permissible amount of current load for sensitive electrical components and devices, and especially semiconductor components, is an almost constant value of the time integral over the square of the load excess current, at very short duration of the excess current, just as in the case of the fusing of the fuse conductor, these components can not be adequately protected in the region of high short circuit currents.

Although it is true that if a particularly high arc voltage is permitted in the fuse, the arcing period of the arc could be shortened, this must be considered with the fact that electrical applicances which might be connected in parallel therewith can only withstand a certain amount of voltage.

A device for protecting sensitive electrical devices as well as for protecting semiconductor elements is known in the art in which, when there is a disturbance, the component to be protected or the operating voltage source is bridged by a mechanical contact which may be termed a short-circuiter, so that the excess current is commutated into a side path and the component is thus bypassed by means of the short-circuiter. Also, with this device overloading with respect to the voltage of components which may be connected in parallel is avoided. However, such short-circuiters have a larger amount of inertia with respect to their responses as compared to safety fuses, and they require a larger amount of circuitry for their operation.

With these defects of the prior art in mind, it is a main object of the present invention to provide a fuse element which combines the advantages of safety fuses and short-circuiters without displaying their disadvantages.

Another object of the invention is to provide a fuse device which, upon overload, operates quickly to prevent current flow to the device to be protected.

These objects and others ancillary thereto are accomplished according to preferred embodiments of the invention wherein a fuse element for protecting sensitive electrical components or devices are preferably semiconductor elements, is constructed to have one or more fuse conductors. The fuse element is provided with at least three electrodes and the fuse conductor or conductors are connected between two of these electrodes. The other auxiliary electrode or electrodes are disposed at a distance which is spaced from the fuse conductor so that in normal operation there is no direct galvanic connection between the auxiliary electrodes and the fuse conductor. When the fuse conductor melts and the arc is created, one or several of the auxiliary electrodes forms a base for the arc which is formed and thus the current path is transferred from the one electrode connected with the fuse conductor to the auxiliary electrode or electrodes.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a diagrammatic view of the fuse device of the present invention.

FIGURE 2 is a circuit diagram indicating a circuit connection for the present invention.

FIGURE 3 is a diagrammatic view of another embodiment of the fuse device.

FIGURE 4 is a diagrammatic view of a further embodiment of the fuse device.

FIGURE 5 is a diagrammatic view of still another embodiment wherein an annular auxiliary electrode is used.

With more particular reference to the drawings, FIGURE 1 shows a fuse device wherein two electrodes **1** and **3** are provided and a fuse conductor **2** is connected therebetween. An auxiliary electrode **4** is arranged close to but spaced from the fuse conductor.

As shown in FIGURE 2, the two electrodes **1** and **3** connect the fuse conductor **2** into the circuit and in series with the electrical component **5** which is to be protected as well as with a source of electrical power and a load such as a resistance. The auxiliary electrode **4** is connected with the portion of the element to be protected which faces away from the fuse conductor in such a manner that the conductor or circuit loop provided by the fuse conductor, the element to be protected, and the auxiliary electrode as well as the connecting lines associated therewith provides an inductance which is as low as possible. When excess current occurs the fuse conductor **2** responds and melts or fuses so that an arc occurs between the two electrodes **1** and **3** or between the ends of the residual fuse conductor portions. Because of the different potentials occurring at electrodes **1** and **3** and at the auxiliary electrode **4** and the forces thereby created, a transfer of the arc onto the auxiliary electrode **4** is provided.

The conductor loop which includes the electrode corresponding with the component to be protected which may be, for example, electrode **3**, the component **5** which is to be protected, the auxiliary electrode **4**, and the connection lines associated therewith has only a very small inductance and therefore only very little electrical energy can be stored in this conductor loop. Because of this the arc between the electrode **3** facing the electrical component to be protected and the auxiliary electrode **4** is extinguished at substantially the same time as transfer of the arc occurs. Thus, the circuit including the component to be protected is already interrupted and the excess current is commutated by means of the auxiliary electrode **4** into the parallel circuit and thus, the component to be protected is bypassed. The arc continues between the electrode facing away from the component to be protected, for example, the electrode **1** and the auxiliary electrode until the voltage necessary for maintaining the arc is no longer present.

A particularly definitive or abrupt response of the fuse conductor and thus an abrupt fusing can be provided by forming, as shown in FIGURE 3, one or more narrow portions or constrictions **6, 6'**, along the fuse conductor. In order to provide an expedient which is particularly advantageous for commutating the arc, one or more auxiliary electrodes **4', 4''**, can be spaced in correspondence with one or several of the constrictions. Also, an advantageous structure is provided if the fuse conductor has constrictions with different fusing characteristics and in this situation an exceedingly advantageous commutation of the arc and thus of the excess current can be provided if the auxiliary electrode or electrodes correspond to the constriction having the smallest cross section.

In order to provide as fast an extinguishing of the commutated arc as possible, the fuse conductor may be embedded in sand or into a similar temperature constant and insulating material with the exception of the fuse conductor portion which is to cooperate with the auxiliary electrode or electrodes.

As shown in FIGURE 4, the fuse conductor may be arranged so that it is provided with two constrictions **6, 6'** disposed parallel to one another and with one or more auxiliary electrodes **4'** disposed therebetween, the magnetic forces created by current flow provide a particularly fast commutation of the two arcs which occur when both constrictions are fused or melted.

Each deflection of the arc created when the fuse conductor responds and melts can be utilized in an advantageous manner for commutating the arc if, as shown in FIGURE 5, the auxiliary electrode **4a** surrounds the fuse conductor so that it may be annular in form to completely encircle the conductor.

It will be understood that the above description of the present invention is susceptible to various modifications, changes, and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. A fuse device for the protection of sensitive electrical components or devices and preferably for use in protecting semiconductor elements, comprising, in combination:

at least one fuse conductor provided with a plurality

of constrictions having different fusing characteristics; and

at least three spaced electrodes, said fuse conductor being connected between two of said electrodes, at least one other electrode being an auxiliary electrode which is disposed to cooperate with the most sensitive constriction and being spaced from said fuse conductor thereby to prevent a direct galvanic connection between the auxiliary electrode and the fuse conductor during normal operation, and to transfer the current from one electrode connected with the fuse conductor to the auxiliary electrode which acts as a base for the arc which is created when the fuse conductor melts.

2. A device as defined in claim **1** wherein all of the fuse conductor outside of the region thereof which is to cooperate with the auxiliary electrode is embedded in a temperature constant insulating material.

3. A device as defined in claim **2** wherein said temperature constant insulating material is sand.

4. A fuse device for the production of sensitive electrical components or devices and preferably for use in protecting semiconductor elements, comprising, in combination:

at least one fuse conductor provided with a plurality of constrictions; and

at least three spaced electrodes, said fuse conductor being connected between two of said electrodes, the other electrode being an auxiliary electrode which is disposed adjacent to and between two adjacent constrictions and which is spaced from said fuse conductor thereby to prevent a direct galvanic connection between the auxiliary electrode and the fuse conductor during normal operation, and to transfer the current from one electrode connected with the fuse conductor to the auxiliary electrode which acts as a base for the arc which is created when the fuse conductor melts.

5. A device as defined in claim **4** wherein said two adjacent constrictions are provided on either side of the fuse conductor.

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