A detonator element of the bridge-type adapted for electrical ignition having two electrodes supported in mutually spaced relationship by an electrically non-conductive support member, a bridging conductor connected across the ends of the electrodes and capable of incandescence or explosive evaporation, and an ignitable charge in contact with the bridging conductor, and further including a mechanically solid semiconductor exhibiting a resistance which is variable depending upon the voltage applied thereto, the semiconductor being disposed electrically in series with one of said electrodes and/or in parallel with the electrodes, the semiconductor additionally or alternatively serving as the means for connecting the bridging conductor across the ends of the electrodes.

12 Claims, 1 Drawing Figure
The present invention relates to a detonator element for electrical ignition or priming, and more particularly to a simplified electronic safety bridge primer.

Copending application Ser. No. 813,873, filed Apr. 7, 1969, by Heinz Gawlick et al., and assigned to the same assignee as the present application, discloses in accordance with the gap detonation principle, having two electrodes electrically interconnected by way of an electrically conductive primer charge, wherein a mechanically solid voltage-dependent semiconductor is electrically connected either in front of the primer charge to control the series current therethrough and/or between the two electrodes which are kept in electrically conductive connection or are insulated from each other to a more or less degree depending on the impedance of the semiconductor as determined by the voltage applied to the electrodes.

Depending on the shape of the resistance characteristics of the selected semiconductor, and how the semiconductor is electrically connected together with the electrically conductive primer charge, the primer element in the known arrangement disclosed in the aforementioned copending application can be protected against unintended ignition due to: (a) stray voltages, surface leakage currents, etc., by providing that the primer element responds only when a correspondingly high-adjusted minimum ignition voltage is reached; (b) electrostatic discharges, by providing that the primer element responds only up to a correspondingly low-adjusted maximum ignition voltage; or (c) both of the foregoing effects (a) and (b), by providing that the voltage causing the ignition of the element is limited in a specific manner with respect to its minimum as well as its maximum.

In a suitable further development of the above-mentioned principles, it is suggested in accordance with the present invention to obtain safety control in a simplified way in connection with a primer element for electric ignition, formed by two electrodes arranged on an electrically non-conductive support member with a bridging conductor connecting these two electrodes with each other in an electrically conductive manner, which conductor is capable of incandescence or of explosive evaporation, as well as with an ignitable charge which is in effective connection with the conductor to be ignited thereby. This is done by providing, in accordance with the invention, a mechanically stable semiconductor with a voltage-dependent resistively electrically connected in parallel and/or in series with the bridging conductor.

As compared to the conventional bridge primers, which are adapted to varying electrical conditions by the provision of conductors having a corresponding electrical resistance, and which are protected against electrostatic discharges by means of a spark gap, as provided in German Pat. No. 1,272,790, it is possible, due to the above-described arrangement of this invention, in a very simple manner, to produce an electronic safety bridge primer distinguished by a very simple structure and a very compact structural volume, and which can be adapted optimally to all requirements, by the selection of semiconductors having appropriate electrical characteristics, to the same extent as the gap primer described in the above-mentioned copending application. By appropriately adjusting the electrical characteristics of the component parts, particularly those of the semiconductor or semiconductors, it is possible, according to the present invention, to permit ignition directly upon reaching a predetermined threshold value, or only after this value has been exceeded, or after a level is attained below the threshold value, by a greater or lesser magnitude.

The constructional design of the primer element with a semiconductor connected in parallel with the bridging conductor becomes particularly simple by providing, according to a further feature of this invention, that the conductor is directly connected to the two metallic coatings of the semiconductor arranged on the support, for example by soldering.

Accordingly, it is an object of the present invention to provide a primer element for electrical ignition which avoids altogether eliminates the disadvantages inherent in similar devices known heretofore.

It is another object of the present invention to provide a primer element for electrical ignition of the bridge-type which is simplified in construction.

It is a further object of the present invention to provide a bridge primer which is effectively rendered safe from unintentional ignition by relatively simple means.

It is still another object of the present invention to provide a bridge primer incorporating one or more semiconductor elements for limiting the values of applicable voltage capable of actuating said primer to a range below a maximum and/or above a minimum.

The invention is shown in the drawing in one embodiment and will be explained in greater detail below with reference thereto.

The two ignition electrodes 5 are passed through the support member 1, which latter is made, for example, of organic plastic material: At points A and B, these ignition electrodes 5 are electrically connected with the electrodes 3a and 3b of the semiconductor 2, which may be conventionally formed by metallic coatings 3a and 3b on opposite faces of a suitable semiconductor material having a voltage dependent impedance characteristic. The semiconductor 2, contacting the support 1, carries on the side facing away from the support 1 the bridging conductor 4, which is also electrically connected to the metallic coatings 3a and 3b and is capable of incandescence or of explosive evaporation in response to an applied current. The conductor 4 is surrounded by the ignitable charge 6, indicated by dot-dash lines.

On the side of the support 1 facing away from the semiconductor 2, the free ends of the ignition electrodes 5 are connected to an ignition generator, now shown. In this connection, an additional semiconductor 7 can optionally be inserted in series with one of the ignition electrodes 5 and the ignition generator.

By virtue of the arrangement of the detonator according to the present invention, with its capabilities of limiting and/or braching the current, it is possible to secure the detonator composition against voltages which are excessive as well as against those which are lower than a predetermined level, depending upon whether the semiconductors employed are of the type wherein the resistance decreases with increasing voltage and, conversely, increases with decreasing voltage, or vice versa.

By utilizing a semiconductor 2, in parallel with the bridging conductor 4, which semiconductor is characterized by resistance varying inversely with the voltage
applied thereto, an arrangement results wherein the detonator is triggered only when a predetermined voltage level, depending upon the electrical characteristics of the particular semiconductor and of the bridging conductor, is exceeded. Conversely, it is also possible to construct the detonator so that ignition is permitted only below a predetermined voltage threshold value by providing a semiconductor which exhibits resistance levels which increase with increasing voltage applied thereto and vice versa. Also, a combination of these effects can be achieved by selection of semiconductors 2 and 7 with suitable characteristics.

Thus, if the semiconductor 2 is selected so as to provide a decrease in resistance with increasing voltage, a maximum threshold value of applied voltage could be obtained above which the shunting resistance of the semiconductor would be too low to permit sufficient current to flow through the bridging conductor to produce ignition. In the same way, if only semiconductor 7 is provided to the exclusion of semiconductor 2, and if semiconductor 7 is selected so that the resistance thereof decreases with an increase in applied voltage, a minimum threshold value of applied voltage could be obtained below which the series resistance of the semiconductor would be too high to permit sufficient current to flow through the bridging conductor to produce ignition. Of course, if both semiconductors 2 and 7 as provided in this example are used, a range of effective voltage values between a minimum and a maximum can be obtained.

As a second example, a minimum threshold of effective voltage values can be established by selecting a semiconductor 2 which provides an increase in resistance with increase in voltage, since initial low values of resistance in parallel with the bridging conductor would prevent sufficient current flow therethrough to effect ignition, while subsequent increase in this shunt resistance with increase in applied voltage will divert more current through the bridging conductor 4 until ignition occurs. In the same way, if only semiconductor 7 is provided to the exclusion of the semiconductor 2, and if semiconductor 7 is selected so as to provide an increase in resistance with an increase in applied voltage, a maximum threshold can be achieved since the series resistance will be initially low and will increase with an increase in the applied voltage until a level is reached where the series impedance will be too high to permit sufficient current to flow through the bridging conductor to produce ignition. Again, if both semiconductors 2 and 7 as provided in this example are used, a range of effective voltage values between a minimum and a maximum can be obtained.

Although the present invention has been described with reference to but a single embodiment, it is to be understood that the scope of the invention is not limited to the specific details thereof, but is susceptible of numerous changes and modifications as would be apparent to one with normal skill in the pertinent technology.

We claim:

1. A primer element for electrical ignition of an ignitable charge comprising a pair of electrodes supported in spaced relationship by an insulating support member, an ignitable bridge conductor electrically connected across said electrodes, said ignitable charge being in connection with said bridge conductor, and semiconductor means providing a resistance which varies in response to variation of the voltage applied thereto being disposed in circuit with said electrodes so as to control the threshold level of voltage for ignition, said semiconductor means supporting said bridging conductor and including at least a first semiconductor element connected in parallel with said igniting voltage, said semiconductor means having metallic coatings on opposite surfaces thereof, said bridging conductor being connected to said pair of electrodes via said metallic coatings on said first semiconductor element.

2. A primer element as defined in claim 1, wherein said semiconductor means provides a resistance which decreases with increase of voltage applied thereto.

3. A primer element as defined in claim 1 wherein said semiconductor means provides a resistance which increases with increase of voltage applied thereto.

4. A primer element as defined in claim 1, wherein said semiconductor means includes a second semiconductor element connected in series with said bridge conductor.

5. A primer element as defined in claim 4, wherein said second semiconductor element provides a resistance which decreases with increase of voltage applied thereto.

6. A primer element as defined in claim 4, wherein said second semiconductor element provides a resistance which increases with increase of voltage applied thereto.

7. A primer element as defined in claim 4, wherein said first and second semiconductor elements each provide a resistance which decreases with increase in voltage applied thereto.

8. A primer element as defined in claim 4, wherein said first and second semiconductor elements each provide a resistance which increases with increase in voltage applied thereto.

9. A primer element as defined in claim 1, wherein said first semiconductor element is physically supported on said insulating support member, said pair of electrodes protruding through said support member being soldered to respective metallic coatings adjacent said support member and said bridging conductor being connected between said coatings at the other end of said first semiconductor element.

10. A primer element as defined in claim 1, wherein said semiconductor means provides a resistance characteristic which is related to the resistance of said bridging conductor such that ignition thereof occurs only after a predetermined value of ignition voltage has been exceeded by a predetermined amount.

11. A primer element as defined in claim 1, wherein said semiconductor means provides a resistance characteristic which is related to the resistance of said bridging conductor such that ignition thereof occurs only below a predetermined value of ignition voltage.

12. A primer element as defined in claim 1, wherein said semiconductor means provides a resistance characteristic which is related to the resistance of said bridging conductor such that ignition thereof occurs only between predetermined maximum and minimum values of ignition voltage.