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SPARK GAP DEVICE WITH IGNITION ELECTRODE

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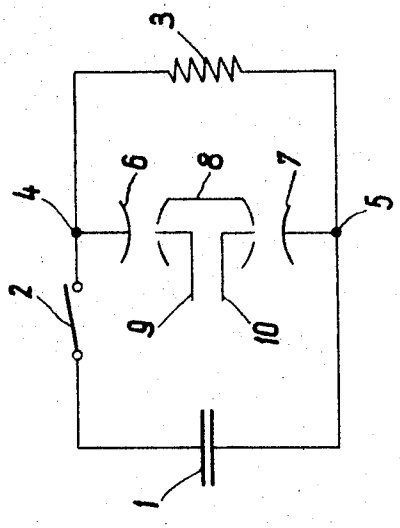


Fig. 1

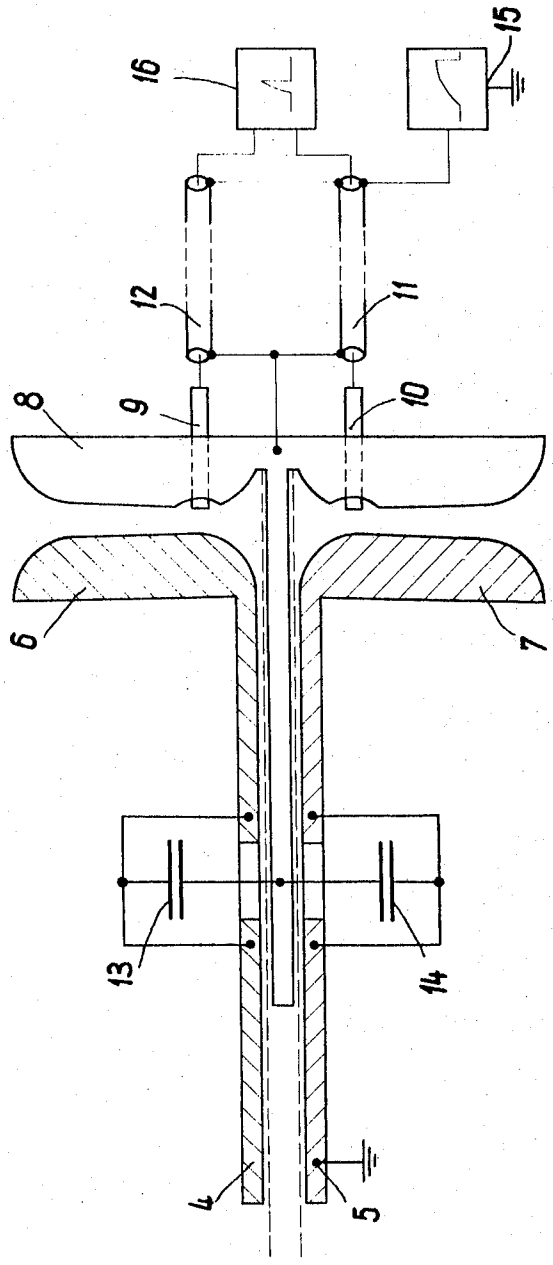


Fig. 2

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SPARK GAP DEVICE WITH IGNITION ELECTRODE

Erwin Marx and Werner Koch, Braunschweig, Germany, assignors to Brown, Boveri & Cie, Aktiengesellschaft, Mannheim-Kafertal, Germany, a corporation of Germany

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U.S. Cl. 315—36 6 Claims

ABSTRACT OF THE DISCLOSURE

Spark gap device includes at least a pair of spaced principal electrodes, an interelectrode associated with the principal electrodes, the interelectrode comprising portions directly connected to one another electrically and spaced from and opposing each of the principal electrodes, and at least one ignition electrode provided at each of the portions and respectively facing the opposed principal electrodes, the ignition electrodes being spaced from and electrically unconnected to the interelectrode portions.

Our invention relates to spark gap devices. More particularly it relates to a spark gap device which may be advantageously utilized as a short circuiting component.

For the purpose of effecting rapid short circuiting in electrical circuits, there are generally employed mechanical switches or gaseous electron discharge devices such as ignitrons, for example. The use of mechanical switches is disadvantageous in many situations since such switches have relatively long switching and control periods. Gaseous electron discharge devices have the advantage of being suitable only where the load current value is relatively slight and in many cases, and for many purposes, their inductance is of an undesirably high value.

Detonator type short circuiting devices, which effectively are of a species of mechanical switches, have been found to be a substantial improvement over the aforementioned devices but they are also limited disadvantageously as to their control period durations, the latter being several 10^{-5} second. In addition, their switching contacts have to be replaced after each operation thereof.

Another type of useful short circuiting device is the three-electrode type spark gap arrangement. However, this type of arrangement presents the disadvantage that there is required for its operation the application of a relatively high voltage between its principal electrodes.

Accordingly, it is an important object of this invention to provide a spark gap device suitable for use as a rapid-acting short circuiting component in an electrical circuit.

It is another object to provide a spark gap device in accordance with the preceding object which is adapted to conductively connect two main electrodes of high load capacity which are inserted into a circuit with little inductance, such connecting being effected within a short time period at a predetermined point of time.

These objects are achieved by providing a spark gap device, according to the invention, in which an additional interelectrode, which is operative to determine the response, is arranged with the two principal electrodes in at least one spark gap path, such interelectrode comprising at least one ignition electrode at each side thereof respectively opposing the principal electrodes. Effectively, with such arrangement, the employment of the additional interelectrode results in two three-electrode spark gaps.

The use of the device, according to the invention, presents many advantages as compared to the use of known

devices employed for a like purpose. Thus, it enables short circuiting within a very short period and at a precisely predetermined moment. Very high current load can be handled and the inductance and resistance of the device are very slight. In addition, since the device does not include any mechanically moving parts, it may be subjected to many switchings, i.e., spark discharges without undergoing much wear and, consequently, is operable for a succeeding switching operation within a short period immediately following a completed preceding switching operation.

The spark gap device, according to the invention, may be particularly advantageously utilized in circuits wherein high value currents have to be respectively produced within short time periods such as in high current techniques or experiments wherein currents have to be maintained at very high or maximum values for relatively long durations. Examples of the immediately foregoing are plasma experiments, the latter type experiments requiring very high current pulses. In these types of experiments, there are typically employed low inductance capacitor batteries as energy storage devices to produce very steep current rises.

Generally speaking and in accordance with the invention, there is provided a spark gap device comprising at least a pair of spaced principal electrodes, an interelectrode associated with the principal electrodes, the interelectrode comprising portions spaced from and opposing each of the principal electrodes, and at least one ignition electrode provided at each of the portions and respectively facing the opposed principal electrodes.

The abovementioned and more specific objects of our invention will be apparent from and will be mentioned in the following description of a spark gap device according to the invention shown by way of example in the accompanying drawing.

In the drawing:

FIG. 1 is a schematic depiction of an arrangement for illustrating the inventive concept; and

FIG. 2 is a schematic showing of an illustrative embodiment of a spark gap device constructed in accordance with the principles of the invention.

Referring now to FIG. 1 wherein there is shown a schematic diagram of a circuit comprising a capacitor storage device and a load which may be inductive, the capacitor storage device **1** is switched into circuit, during the closed position of a switch **2**, with the load **3**. If the circuit is of low inductance and resistance, there will occur therein a weakly damped high frequency discharge. The function of the short circuiting device in this type of circuit is to bridge load **3** by a short circuit path which is of the lowest possible resistance when current is at a maximum, i.e., substantially at the zero voltage crossover point of the discharge. If it is assumed that at such moment, the greater portion of the energy in the oscilltaing circuit is in the inductance of load **3**, then beginning with the instant of the ignition of the short circuit spark gap, the high frequency discharge is largely suppressed.

The current decays in the load in accordance with an experimental function whose time constant is determined by the magnitudes of the inductance and resistances in the load and the short circuit spark gap respectively. A current pulse wave appears in load **3**. In this manner, capacitors **1** are protected, since capacitors with low inductance are sensitive to rapid polarity changes in the voltage.

Short circuiting, for example, between points **4** and **5** in the circuit of FIG. 1 may be effected with the spark gap device according to the invention. The invention comprises the principal electrodes **6** and **7**, and interelectrode **8** which is provided with the ignition electrodes **9** and **10**. In this example, the ignition electrodes extend through the interelectrode and are insulated therefrom. Such in-

sulating may be achieved, for example, with a ceramic tube (not shown). A small ceramic tube presents the advantage of being only slightly burned off by hot gases.

The abovementioned ignition occurring at the null voltage crossover point is produced as a result of the fact that the interlectrode 8 has applied thereto an additional voltage from a voltage source (not shown) which increases the voltages in patht 6—8 and 7—8 respectively by at least one half of the static response voltages for such gaps. At the switching point, ignition electrodes 9 and 10 receive an ignition pulse which at first effects a spark over to the opposingly disposed main electrodes 6 and 7. This first ignition pulse is followed by a sparkover to the adjoining interelectrode 8. With such switching arrangement, there can be ensured a faultless simultaneous ignition of the whole device. The switching and control periods of the instant of switching may be a few 10^{-8} second. The arrangement as shown in FIG. 1 and hereinabove described enables the achieving of short circuiting, precisely at maximum current, even where there is a high frequency, weakly damped discharge.

The embodiment of the spark gap device constructed in accordance with the principles of the invention and shown in FIG. 2, comprises the spaced main electrodes 6 and 7, an interelectrode 8 ignition electrodes 9 and 10 the separate supply cables 11 and 12 through which there are transmitted the ignition and supplemental pulses, the two symmetrical capacitors 13 and 14 and the junction buses or rails which are to be conductively connected by the short circuiting effected through the operation of spark gap device.

In design application which cannot be effectively operated with normal switching devices, the voltage between points 4 and 5 is equal to or almost equal to zero, as mentioned hereinabove, if a conductive connection is to be produced. In order to obtain a substantially perfect ignition of the device under these circumstances, a supplemental voltage is applied to interelectrode 8. This supplemental voltage is provided from an ignition generator 15 and is supplied to interelectrode 8 through the jacket of the ignition cables 11 and 12 to build up an electric field between electrodes 6 and 8, and 7 and 8 respectively. At the desired instant of switching, very steep voltage pulses are applied to ignition electrodes 9 and 10 from ignition generator 16. These ignition pulses produce virtually simultaneously occurring spark-overs between electrodes 9 and 6, and 10 and 7 respectively. After the production of these sparks, i.e., light arcs, the potential at ignition electrodes 9 and 10 assumes a value virtually equal to the potential at main electrodes 6 and 7, to produce a relatively high magnitude difference of potential at paths 9–8 and 10–8 which, as yet, are not conductive. With the selection of the appropriate dimensions, the spark-overs at the last-named paths occur substantially simultaneously in a control time under 10 ns. The load of capacitors 13 and 14 functions to maintain the potential at interelectrode 8 at an adequate value during short scattering periods. Capacitors 13 and 14 are operative to distribute, as desired, along paths 6–8 and 8–7, the voltages occurring in normal operation at points 4 and 5, prior to the ignition of the short circuiting spark gap.

The operation of the spark gap device in the so-called short-time mode is necessary for the guaranteed functioning of the device, i.e., spark-overs between electrodes 9–6 and 9–8, and 10–7 and 10–8 respectively directly following each other. This short-time mode of operation is achieved if the value of the applied supplemental voltage is almost as great as the static response voltage of the spark gap. However, if the dimensioning principle is followed, i.e., that the respective spacings between the ignition electrodes 9 and 10 and interelectrode 8 are to be half as great as the spacings between ignition electrodes 9 and 10 and the main electrodes 6 and 7 respectively, then such short-time mode or mechanism may be obtained with operating voltages which have values as low as 50 percent of the static response voltage. Only such dimensioning provides results in safe operation at various voltage widths. At longer time scatterings or distributions of the individual spark gaps, either the potential at interelectrode 8 should be very fixedly controlled and maintained or the interelectrode 8 should be divided and be decoupled through running time connections. With the use of the short-time mechanism, only a short-time running time coupling need be present.

The switching preciseness and the certainty of proper operations are increased when the supplemental voltage and the ignition voltage are simultaneously produced in a unitary generator. With such arrangement, the ignition pulse can be applied to the device through a delay cable. The use of three-conductor coaxial cables for the transmission of the supplemental voltage and ignition pulses in a unit provides a further improvement in the operation.

Unequal values of capacitors 13 and 14 respectively may cause a displacement of the voltage range. However, the normal situation is for capacitors 13 and 14 to be designed to be of equal magnitudes. If the switching is always to be effected during the first current maximum of the capacitors discharge, then it is sufficient to only connect one capacitor parallel to one spark gap. In such case, the interelectrode may be fixedly loaded on the supplemental voltage with the use of one capacitor.

It has been found advantageous with regard to the length of the lifetime of the device to effect its construction such that the switching arc light currents repel each other. With this arrangement, the arc light base points are repelled from the region which is exposed to burning as well as from the ignition electrode and the burning off is reduced because of the migration of the light arc base point.

Since, in every case, the device is provided with switching light arcs, its resistance is considerably higher than that of mechanical switches, for example. The parallel connection of the considerably slower mechanical switches is therefore suggested for the device in particular applications. The use of the device under conditions of either reduced pressure or increased pressure enables the reduction of the electrode spacings and thereby a reduction of the resistance and inductance of the device. Combinations with quenching devices may be required to form the pulse discharge mentioned in the example to protect the capacitors and for the supplemental connection of additional energy storage devices.

It will be obvious to those skilled in the art, upon studying this disclosure, that spark-gap devices according to our invention, permit of a great variety of modifications and hence can be given embodiments other than that particularly illustrated and described herein, without departing from the essential features of our invention and within the scope of the claims annexed hereto.

We claim:

1. A spark gap device comprising at least a pair of spaced principal electrodes, an interelectrode associated with said principal electrodes, said interelectrode comprising portions directly connected to one another electrically and spaced from and opposing each of said principal electrodes, and at least one ignition electrode provided at each of said portions and respectively facing said opposed principal electrodes, said ignition electrodes being spaced from and electrically unconnected to the interelectrode portions.

2. A spark gap device as defined in claim 1 wherein the distances between the ignition electrodes and the interelectrode respectively are equal to half the distances between said ignition electrodes and said principal electrodes.

3. A spark gap device as defined in claim 1 wherein there is further included a supplemental voltage source for application of a supplemental voltage therefrom to

said interelectrode prior to the ignition of the spark gap.

4. A spark gap device as defined in claim 3 wherein there is further included an ignition pulse source for application of an ignition pulse voltage to said ignition electrodes, said ignition pulse being superimposed over said supplemental voltage, and delay lines through which said supplemental voltage and said ignition pulse voltage are applied.

5. A spark gap device as defined in claim 3 and further including respectively equal value capacitances respectively connected in parallel with said principal electrodes.

6. A spark gap as defined in claim 1 wherein said principal electrodes are constructed in the form of guide rails.

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JOHN W. HUCKERT, *Primary Examiner.*

A. J. JAMES, *Assistant Examiner.*

U.S. Cl. X.R.

313—306, 307, 325; 317—62

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,454,823 July 8, 19(

Erwin Marx et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading to the printed specification, line 9, "M 63,655" should read -- M 63,665 --.

Signed and sealed this 28th day of April 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents