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DISCHARGE GAP

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FIG. 1.

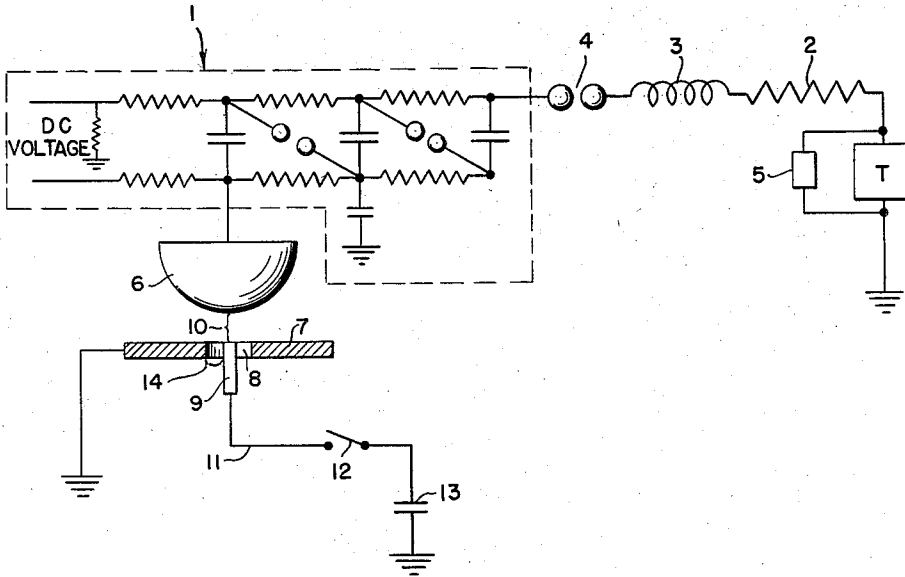
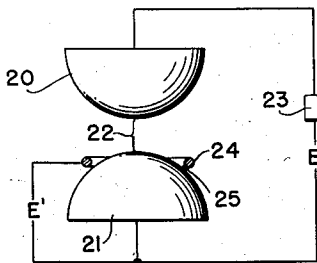


FIG. 2.



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DISCHARGE GAP

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4 Claims. (Cl. 313—231)

The present invention relates to a discharge gap structure, and especially pertains to an auxiliary tripping gap electrode for controlling discharge voltage in a main power circuit.

Three-electrode discharge gap structures are well-known, and have been used extensively for protecting electric circuits from high voltage surges, and also in connection with surge generators and cathode ray oscillographs. In recent years the thyatron electron tube has also been introduced for use in high voltage, high current circuits.

The present structure operates in a manner somewhat analogous to the thyatron tube, and effectively supplements the operation of these tubes. The present device may be built for relatively higher voltages and current values and at considerably less manufacturing expense than thyatron tubes. In addition, the present invention provides a three-electrode gap structure which does not need a heated filament, nor does it necessarily have to be placed in an hermetically sealed container to operate effectively.

In discharge devices of the present type, the main gap electrodes are normally non-conducting as long as the control voltage remains below a given limit. However, when the control voltage (the grid voltage in the case of thyatron tubes) is increased, the discharge is effected between the main gap electrodes and the main gap electrodes become conducting. Once the device becomes conducting, control of the current is lost by the device, and is then determined by the remainder of the circuit. Current flow continues until the circuit is interrupted by some component electrically associated with the main gap electrodes.

It is among the objects of the present invention to provide a three gap electrode structure utilizing an auxiliary control gap electrode positioned in the proximity of one of two cooperating main gap electrodes to jointly provide a control gap with that one electrode to act as a means for initiating sparkover across the main gap and being responsive to an initiating potential differing in magnitude from the main discharge voltage.

It is another object of the present invention to provide a three electrode gap structure wherein one electrode jointly cooperates with a control electrode to define a discharge initiating auxiliary gap, which structure is adapted to be discharged relatively independent of atmospheric changes such as temperature and barometric pressure variations which have materially affected operation of discharge gaps in the past, and which is not dependent upon the formation of corona as an initiating atmosphere.

It is a further object of this invention to provide a three electrode gap structure including a control gap defined by a main gap electrode and an auxiliary electrode, the control gap being located proximate to the main discharge gap and acting as a means for initiating

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sparkover between the main circuit electrodes on being caused to sparkover at a control electric potential.

In the drawing:

Fig. 1 is an elevational view partly in diagram and partly in section illustrating one embodiment of the present invention as used in marx circuit generator circuit.

Fig. 2 is an elevational view, partly in section of another embodiment of the present invention.

In the drawing, a preferred embodiment is illustrated in Fig. 1, wherein the device is used in conjunction with an impulse generator circuit having particular application to the testing of transformer insulation.

A surge generator, or impulse generator, generally comprising a bank of condensers, is diagrammatically represented, and generally denoted by the reference character 1. This is the main source of the test surge applied to the test specimen T, such as a distribution transformer, or the like. The circuit adjusting constants are diagrammatically shown by the resistor 2 and the inductor 3. The gap 4 is provided to isolate the specimen from the generator during the charging period. The voltage measuring circuit is diagrammatically denoted by the reference character 5, and may include many of the known measuring devices such as a cathode ray oscillograph circuit.

Fig. 1 exemplifies one form of a marx circuit surge generator. The surge generator may take several forms and circuit arrangements in a manner well-known in the art.

The novel three-electrode gap structure for discharging the surge generator is illustrated by the hemispherical cap electrode 6 and the plate gap electrode 7. The plate electrode is provided with a transverse opening 8 adapted to receive an auxiliary gap electrode 9 centrally thereof. The main discharge gap is indicated by the reference character 10, and is defined by the extremity of the electrode 6 and the upper surface of the plate electrode 7. An auxiliary tripping circuit is designated at 11 and comprises a circuit connecting means in the form of a switch 12 and an auxiliary surge generator 13 to be used in purposes hereinafter described. An auxiliary discharge gap 14 is provided between the marginal surface of the opening 8 in the electrode 7, and the auxiliary electrode 9.

It is understood that three electrode gaps have long been used, and have found particular use in the field of impulse testing. However, the electrodes, heretofore, have generally comprised three spherical or hemispherical members defining two gap portions therebetween. The adjustment of the gaps of the voltage of the main or power circuit was very critical for proper gap operation. In addition, the ratio of voltages and the power to the control circuits over which the gap operated was very limited. The control electrode, which was usually spherical in form, was placed in the arc of the power circuit, and therefore was subjected to eroding conditions from the high current, with the result that the gap sparkover characteristics changed as the device was being used.

Another well known form utilized two hemispherical gap electrodes with a control electrode consisting of a sharp point extending part way into the gap space between the main electrodes. The control voltage was depended upon to produce corona from the sharp point, and that corona ionized the main gap. Disadvantages to this construction were that corona was used rather than an auxiliary discharge gap to ionize the main gap, and the action of the gap was not positive. Adjustment of the gap spacing for the voltage of the power circuit was very critical for proper operation, and the ratio of

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the main voltage over the control voltage was very limited. In addition, the control electrode was again positioned in the path of the arc from the main gap and the sharp point eventually burned off.

As shown in Fig. 1, the gap 10 is normally non-conducting, and prevents current flow in the main circuit as long as the main gap is large enough to withstand the voltage of this circuit. By applying a sufficient voltage through the auxiliary circuit generator through the control electrode 9, the control gap 14 will spark over. It will be obvious that since the gap 15 is relatively shorter than the main gap 10, the voltage needed to spark over the auxiliary gap may be of considerably less magnitude than the main gap voltage. The arc in the control gap will ionize the main gap to initiate sparkover in this gap and cause current to flow in the main circuit. After current flow starts in the main gap, the control of this current is determined entirely by the characteristics of the power circuit as arranged according to conventional practice. After the main gap 10 is caused to spark over, the circuit connecting means 12 in the auxiliary circuit 11 may be opened if so desired.

It is of particular importance to note that the control electrode 8 is completely out of the path of the main discharge created across the gap 9, although the control gap 14 is in definite communication with the main gap. Thus there is less chance for the electrode to become eroded during discharge of the main circuit.

Another embodiment of the novel three-electrode gap is illustrated in Fig. 2 of the drawing, wherein the main discharge electrodes may take the form of conducting hemispherical members 20 and 21. The main discharge electrodes 20 and 21 provide the main circuit discharge gap 22 therebetween. The main circuit is denoted generally by the reference character E, which also refers to the main discharge voltage. The circuit adjusting constants are diagrammatically denoted by the reference character 23, and they may take the form shown in Fig. 1, including the various members 2, 3, and 4. The control circuit is denoted by the reference character E' and has one end connected to the auxiliary control electrode 24. The control electrode, in this case, is preferably a closed toroid, and provides a concentric control gap 25 with the electrode 21.

The present embodiment functions in substantially the same manner as the first-described structure. That is, the auxiliary circuit E' is completed through its surge source to cause a discharge across the control gap 25 which discharge ionizes the main gap 22 to permit an electric discharge through the main circuit components 23.

It is to be understood that though the three-gap electrodes illustrated in both embodiments have particular adaptation to impulse testing apparatus, the device may also be used in conjunction with lightning arrester structures and other devices wherein a precisely controlled discharge gap is preferred.

It will be apparent that a novel three-electrode gap structure has been provided by this invention which incorporates the desired features of conventional gaps, and in addition, provides the precise control desired without the disadvantages inherent in previous structures. The control electrode is utilized to ionize the main gap, and is not dependent upon corona, and is not located within the path of the discharge which might deleteriously affect the control electrode unit. In addition, the ratio of the main discharge voltage over the control voltage is considerably increased by the structural arrangement.

I claim:

1. In electrical apparatus having a main electrical circuit, in combination, a pair of unheated discharge electrodes positioned in spaced relationship and jointly providing therebetween an unobstructed predetermined main discharge air gap connected in said main circuit and normally preventing current flow therein, at least one of

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said discharge electrodes having a large convex surface facing the other said discharge electrode, an unheated auxiliary control electrode disposed in coaxial and radially spaced relationship with one of said discharge electrodes and normally being electrically unbiased relative thereto to jointly provide an auxiliary control air gap therebetween, said control electrode being out of the discharge path defined by the minimum air gap dimension between said discharge electrodes, the spacing between said control electrode and said discharge electrode radially spaced therefrom being considerably less than the spacing between said discharge electrodes and the sparkover potential of said auxiliary control air gap being considerably lower than the sparkover potential of said main discharge air gap, the sparkover of said auxiliary control air gap, incident to change of potential of said control electrode relative to said discharge electrode radially spaced therefrom, ionizing said main air gap and lowering the breakdown potential of said main air gap, whereby current flow may be initiated in said main electrical circuit by triggering said control air gap.

2. In combination with electrical apparatus having a main electrical circuit, a pair of unheated discharge electrodes positioned in spaced relationship and jointly providing therebetween an unobstructed predetermined main discharge air gap connected in said main circuit and normally preventing current flow therein, at least one of said discharge electrodes having a large convex surface disposed toward the other said discharge electrode, one of said discharge electrodes having an opening therein in the vicinity of the least air gap dimension between said discharge electrodes, an unheated control electrode disposed in said opening and jointly providing a substantially annular auxiliary control air gap with said discharge electrode having said opening, the spacing between said control electrode and said discharge electrode having said opening being considerably less than the spacing between said discharge electrodes and the sparkover potential of said auxiliary control air gap being considerably lower than the sparkover potential of said main discharge air gap, said control electrode normally being at approximately the same potential as said discharge electrode having said opening, and means for changing the potential of said auxiliary control electrode sufficiently relative to that of said one electrode member having said opening to break down said control air gap, the sparkover of said control air gap ionizing the main air gap between said discharge electrodes and lowering the sparkover potential of the main air gap.

3. In combination with electrical apparatus having a main electrical circuit, a pair of unheated discharge electrodes positioned in spaced relationship and jointly providing therebetween an unobstructed predetermined main discharge air gap connected in said main circuit and normally preventing current flow therein, said discharge electrodes diverging in directions outward from the discharge path of least dimension between said electrodes, an unheated control electrode ring spaced from and embracing a portion of the peripheral surfaces of one only of said discharge electrodes to jointly provide a control air gap therebetween, the spacing between said control electrode ring and said one discharge electrode being considerably less than the spacing between said discharge electrodes and the sparkover potential of said control air gap being lower than the sparkover potential of said main discharge air gap, the sparkover of said control air gap, incident to change of the potential of said control electrode relative to that of said one discharge electrode, altering the voltage gradient in the vicinity of said least air gap between said discharge electrodes and lowering the sparkover potential of the main air gap, whereby current flow may be initiated in said main electrical circuit by triggering said control air gap.

4. In combination with electrical apparatus having a main electrical circuit, unheated first and second dis-

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charge electrodes positioned in spaced relationship and jointly providing therebetween an unobstructed predetermined main discharge air gap connected in said main circuit and normally preventing current flow therein, said first discharge electrode having a large convex surface facing said second discharge electrode, said second discharge electrode being a plate-like member, one of said discharge electrodes having an opening therein communicating with said main discharge air gap in the proximity of the least air gap dimension defined by said discharge electrodes, an unheated auxiliary control electrode disposed in said opening to jointly provide a substantially annular auxiliary control air gap with said one electrode, said auxiliary control electrode normally being maintained at approximately the same potential as said one electrode, the spacing between said one discharge electrode and said control electrode being considerably less than the spacing between said discharge electrodes and the sparkover potential of said auxiliary control air gap being lower than the sparkover potential of said main

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discharge air gap, the discharge across the control air gap, incident to change of potential of said control electrode relative to said one discharge electrode, altering the voltage gradient in the vicinity of the least air gap dimension between said discharge electrodes and lowering the sparkover potential of the main air gap.

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