

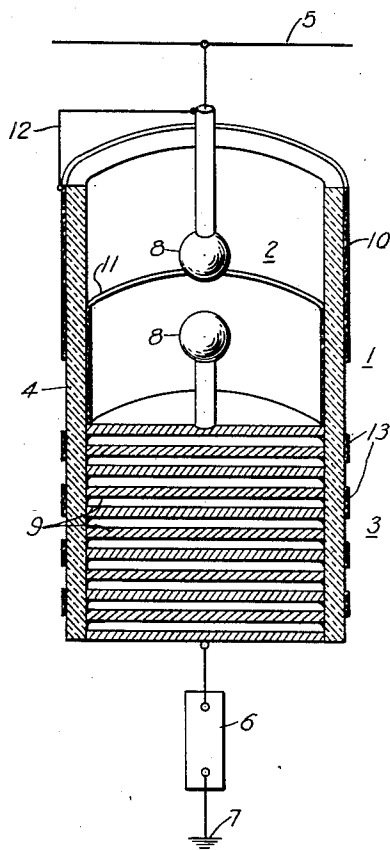
Oct. 6, 1942.

W. ESTORFF

2,298,114

SPARK GAP DEVICE

Filed Aug. 3, 1940



WITNESSES:

Wm. C. Milham
F. P. Lytle

INVENTOR

Walther Estorff

BY *O. R. Buchanan*

ATTORNEY

UNITED STATES PATENT OFFICE

2,298,114

SPARK GAP DEVICE

Walther Estorff, Berlin-Charlottenburg, Germany, assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application August 3, 1940, Serial No. 351,035
In Germany July 3, 1939

4 Claims. (Cl. 175—30)

The present invention relates to spark gap devices, and more particularly to high voltage gaps of either the single or multiple type such as are used in lightning arresters.

The principal object of the invention is to provide a spark gap device having a very low impulse ratio. The impulse ratio of a spark gap is defined as the ratio of the surge breakdown voltage, under a surge rising at a specified rate, to the 60-cycle or normal frequency breakdown voltage. This ratio is an important characteristic of spark gaps which are to be used in lightning arresters, since, in order to obtain the greatest degree of protection, it is necessary for the gap to break down as rapidly as possible when a lightning surge occurs, while the normal frequency breakdown voltage should be as high as possible in order to prevent operation of the gap at the normal line voltage or on low-voltage disturbances, such as may be caused by switching operations. A low impulse ratio is, therefore, highly desirable in lightning arrester spark gaps.

Another object of the invention is to provide a spark gap structure in which a capacitive shunt is provided for the purpose of controlling the distribution of voltage across the gap, and to bring about changes in the voltage distribution at different frequencies, so as to obtain the desired breakdown characteristics.

A more specific object of the invention is to provide a multiple spark gap structure which is especially adapted for use in lightning arresters and in which high resistance elements are arranged to form capacitive shunts for the gap to control the voltage distribution across it in order to obtain a low impulse ratio.

Further objects and advantages of the invention will be apparent from the following detailed description, taken in connection with the accompanying drawing, the single figure of which is a perspective sectional view of a spark gap device, with the associated apparatus shown diagrammatically.

The invention is shown in the drawing in connection with a spark gap for a lightning arrester of the so-called valve type. Arresters of this type consist essentially of a spark gap device connected in series with a valve or resistance element between a transmission line, or other device to be protected, and ground. The resistance element preferably has valve characteristics; that is, it is substantially a non-conductor or at least has extremely high resistance at normal voltages, but has the property of changing to a very low resistance when the voltage applied to it rises

above a predetermined value. The function of the spark gap connected in series with the valve element is to isolate it from the line under normal conditions and to break down and connect it to the line when a voltage surge occurs, in order to permit the surge to be discharged to ground. After the surge has passed, the gap interrupts the relatively small current which tends to flow through the high resistance of the valve element and again isolates the arrester from the line.

The gap device 1 shown in the drawing comprises a switch gap element 2 and a quench gap portion 3 which are connected in series and mounted in a tube 4 of suitable insulating material, such as porcelain. The gap device 1 is connected in series between a transmission line conductor 5 and a resistance or valve element 6 which, in turn, is connected to ground, as indicated at 7. The complete arrester, consisting of the gap device 1 and valve element 6, may be mounted in a suitable porcelain housing in the usual manner, if desired.

The switch gap element 2 of the spark gap device 1 consists of spaced spherical electrodes 8, the function of which is to interrupt the relatively small leakage current after a surge has been discharged, and thus disconnect the arrester from the line. The quench gap portion 3 of the spark gap device 1 consists of a plurality of generally disc-shaped electrodes 9 supported in the tube 4 to form a multiple gap structure, the function of which is to reduce the current flowing through the arrester after a surge has passed to a very small value which can be readily interrupted by the switch gap 2.

In order to control the voltage distribution across the gap device, a capacitive shunt is provided for the switch gap 2. This shunt is most conveniently provided by placing a layer of high resistance or semi-conducting material 10 on the outside surface of the tube 4 and a similar layer 11 on the inside surface. These layers 10 and 11 are arranged to overlap, as shown in the drawing, and are insulated from each other by the tube 4. The layer 10 is connected to the upper electrode 8, as indicated at 12, while the other layer 11 is connected to the lower electrode 8 through the uppermost electrode 9 of the quench gap portion so that the two layers constitute a capacitive shunt connected across the gap 2.

With this arrangement, when a voltage of normal frequency, such as 60 cycles, is applied to the spark gap device 1, the distribution of voltage across the spark gap is such that the largest part of the voltage drop occurs across the quench

gap portion 3. When a high-frequency voltage or a rapidly rising impulse voltage is applied to the gap, however, the effect of the capacitive shunt will be to cause a different distribution of the field, and a larger proportion of the total voltage will appear across the switch gap 2, thus causing it to break down very rapidly since the voltage across it rises faster than the rate of rise of the total voltage across the gap device 1, because of the change in distribution of voltage between the switch gap 2 and the quench gap 3. For this reason, very much lower surge breakdown voltages can be obtained with this gap than are usually obtainable with conventional spark gap structures, and impulse ratios as low as unity or less than unity are readily obtained.

A similar effect can be utilized to control the distribution of voltage across the quench gap 3. Thus, bands or narrow layers 13 of high resistance or semi-conducting material may be placed on the outside of the tube 4 opposite the gap spaces of the quench gap portion 3, and these bands do not need to be connected to the electrodes 9, but will affect the distribution of voltage across the multiple gap assembly 3 because of their capacitive effect. By suitably locating these bands, any desired distribution of the voltage can be obtained so as to obtain the desired breakdown characteristics. A plurality of individual annular bands can be used or a single long strip of semi-conducting material can be wrapped around the tube 4 in the form of a helix to provide the same effect. In either case, the spacing between successive bands or between successive turns of the helix may be made different in different parts of the gap, so that by suitably proportioning the widths and location of the various bands and the spacings between them, any desired distribution of voltage can be obtained so as to give the gap any desired breakdown characteristics. The high-resistance elements which form the capacitive shunts can also be arranged so that the separate gaps of the gap structure can be shunted individually or in groups.

Any suitable material may be used for the layers 19 and 11 and the bands 13, but it should preferably be a material of very high resistance or a semi-conducting material. It has been found that asbestos is a very suitable material for this purpose, since it can readily be obtained in the form of thin sheets which are suitable for application to the insulating tube 4, and it is a semi-conducting material of extremely high resistivity. The characteristics can be further improved by impregnating the asbestos layers with a suitable lacquer to further increase their resistance and also to serve as an adhesive to secure them in position on the tube 4.

It will be seen, therefore, that a spark gap device has been provided which is of relatively simple structure, but which has a very low impulse ratio, and in which the distribution of voltage across the gap is controlled by the use of a capacitive shunt or shunts so that any desired breakdown characteristics can be obtained by suitable arrangement of these shunts. The use of a capacitive shunt to control the voltage distribution in this manner has the advantage over the resistance shunts that have been used in the prior art that the voltage distribution across the gap is changed when the frequency of the applied voltage is changed, so that very low impulse ratios are possible. It also has the advantage that there is no leakage current under normal operat-

ing conditions such as occurs with a resistance shunt.

It is to be understood that the invention is capable of various modifications and embodiments, and is not limited to the specific arrangement or type of spark gap shown in the drawing. Thus, the invention is of general application and is suitable for spark gaps of any type where it is desired to control the voltage distribution or to obtain a low impulse ratio. The invention is not restricted, therefore, to the particular embodiment shown and described for the purposes of illustration, but in its broadest aspects it includes all equivalent embodiments and modifications which come within the scope of the appended claims.

I claim as my invention:

1. A spark gap device comprising a tube of insulating material, a pair of spaced electrodes supported in said tube to form a spark gap between them, a plurality of other electrodes supported in the tube to form a multiple gap structure and disposed in series relation with the first-mentioned electrodes, and bands of semi-conducting material placed on the outside surface of said tube, said bands being disposed to form capacitive shunts for said gap device to control the voltage distribution.

2. A spark gap device comprising a tube of insulating material, a pair of spaced electrodes supported in said tube to form a spark gap between them, a plurality of other electrodes supported in the tube to form a multiple gap structure and disposed in series relation with the first-mentioned electrodes, and layers of semi-conducting material on the surface of the tube, said layers being disposed opposite said gaps to form capacitive shunts therefor to control the voltage distribution over said spark gap device.

3. A spark gap device comprising a tube of insulating material, a pair of spaced electrodes supported in said tube to form a spark gap between them, a plurality of other electrodes supported in the tube to form a multiple gap structure and disposed in series relation with the first-mentioned electrodes, a layer of semi-conducting material on the outside surface of the tube and connected to one of said first-mentioned electrodes, a layer of semi-conducting material on the inside surface of the tube and connected to the other of said first-mentioned electrodes, said layers being disposed so that they overlap, and bands of semi-conducting material on the outside surface of the tube opposite said multiple gap structure.

4. A spark gap device comprising a tube of insulating material, a pair of spaced electrodes supported in said tube to form a spark gap between them, a plurality of other electrodes supported in the tube to form a multiple gap structure and disposed in series relation with the first-mentioned electrodes, a layer of semi-conducting material on the outside surface of the tube and connected to one of said first-mentioned electrodes, a layer of semi-conducting material on the inside surface of the tube and connected to the other of said first-mentioned electrodes, said layers being disposed so that they overlap, and bands of semi-conducting material extending around the tube opposite said multiple gap structure to form capacitive shunts and control the voltage distribution across the gap.

WALTHER ESTORFF.