Sept. 3, 1963 F. WATERTON 3,102,968

VACUUM SPARK GAP DEVICE HAVING COMPOSITE ELECTRODES

Filed Oct. 26, 1961

FIG.1.

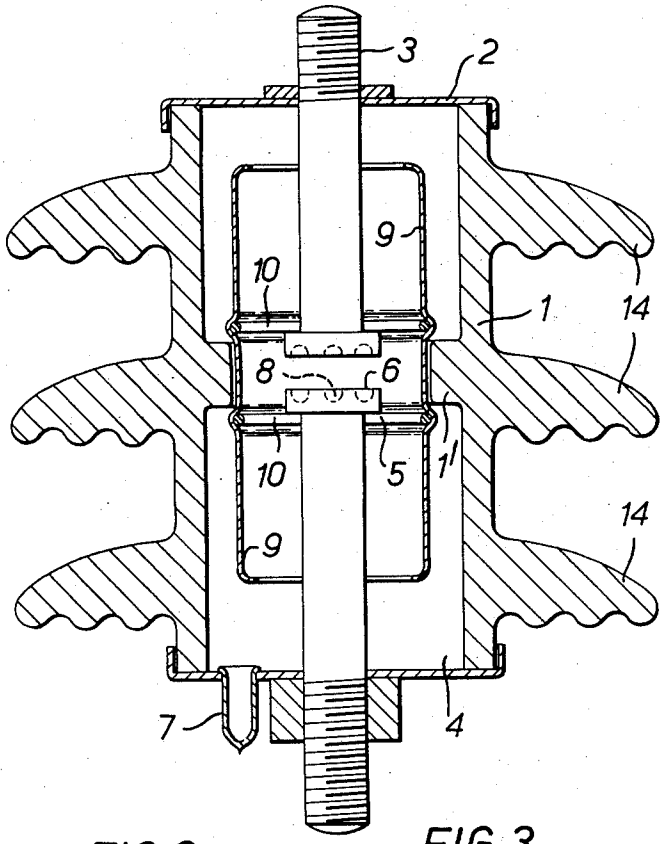


FIG.2.

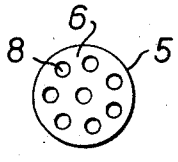
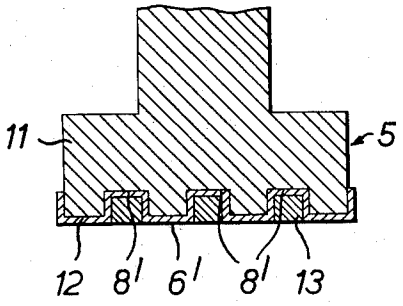


FIG.3.



United States Patent Office 3,102,968 Patented Sept. 3, 1963

3,102,968

VACUUM SPARK GAP DEVICE HAVING COMPOSITE ELECTRODES

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Filed Oct. 26, 1961, Ser. No. 147,779
Claims priority, application Great Britain Oct. 5, 1961
8 Claims. (Cl. 313—311)

The present invention relates to vacuum spark gap devices, that is, devices in which a spark gap is defined within an evacuated enclosure.

Vacuum spark gap devices find use, for example, in surge divertors which comprise a series circuit relationship of one or more spark gaps and a current limiting resistor connected for protecting an electricity supply system so that damage to the electrical insulation or apparatus of the system by excess voltage, as may be caused by a lightning stroke, can be prevented.

Spark gap devices for use in such surge divertors are required to spark over when a surge voltage exceeds a predetermined value, which is slightly less than a maximum permissible voltage and to fail to spark over when the normal voltage of the supply system is applied. A vacuum spark gap device has a spark-over or "breakdown" voltage which is dependent on the spacing between its electrodes. The curve of break-down voltage plotted against electrode spacing is not linear, but initially rises steeply with increasing electrode spacing, after which the curve becomes asymptotic to some value of breakdown voltage which is largely determined by the material from which the electrodes are made. Due to the steep rise of this curve over its initial portion, it is difficult to manufacture a vacuum spark gap device having an accurately determined breakdown voltage of a desired value if this voltage falls within that portion of the curve, owing to the critical spacing then required for the electrodes. Furthermore, with the breakdown voltage lying on the steep portion of the curve, any changes in the effective electrode spacing, resulting for instance from the discharge surfaces becoming burnt away during use, will produce in consequence a relatively large change in the breakdown voltage. According to the invention a vacuum spark gap device has its gap defined between composite electrodes each of which comprises a part presenting a reference surface of one metallic material and carrying a quantity of another metallic material exposed to the other electrode at a position adjacent to said surface, the second material being characteristic of a lower arcing voltage than is the first material: preferably the material characteristic of the lower arcing voltage may be contained in one or more cavities in the reference surface but alternatively or in addition it may be provided as a coating layer on the reference surface.

It is preferable that the material used for the reference surface should have a higher melting point than the other material in order to prevent diffusing of the latter into it during use, it being appreciated that each time the gap breaks down during use the resultant arc between the electrodes will heat them to a considerable temperature. By way of example, the reference surface may be formed from a refractory metal such as molybdenum, and the material of lower arcing voltage may be a nickel/tin alloy which has also a lower melting point than molybdenum.

In carrying out the invention one of the materials used for the composite electrodes, for example the nickel/tin alloy mentioned, may also have gettering properties so that it tends to absorb gases which may be produced on arcing.

An advantage of the invention is that by appropriate

choice of the lower arcing voltage material it can be arranged that the voltage range covered by the asymptotic portion of the curve of breakdown voltage to electrode spacing includes the desired breakdown voltage, so that the electrode spacing is less critical than it would otherwise be.

Furthermore an arc produced between the composite electrodes of a vacuum spark gap device according to the invention will tend to root itself on the exposed material of lower arcing voltage. Eroding action of the arc on the reference surfaces of the electrodes will therefore be delayed so that these surfaces will define a gap of substantially constant dimensions for a relatively long time. When the material of lower arcing voltage is contained in cavities in the reference surface, substantialy the whole of the reference surface becomes coated with this material due to vaporisation and subsequent condensation of the material as a result of arcing. The cavities provide reservoirs of the material, from which any portions of the coating which are burnt off the reference surface are replaced as a result of this vaporisation and subsequent condensation.

In order that the invention may be more clearly understood reference will now be made to the accompanying drawing in which:

FIG. 1 shows in partial section, an example of a vacuum spark gap device embodying the invention;

FIG. 2 shows a front end view of a composite electrode shown in elevation in FIG. 1; and

FIG. 3 shows in section, an alternative form of a composite electrode shown in FIG. 1.

Referring in the first instance to FIGS. 1 and 2, a vacuum spark gap device comprises an insulating envelope **1** which can be of glass or of porcelain, or other ceramic material, having metal end caps **2** sealed to each of its axially opposite ends to form an air-tight chamber **4**. Two conductors **3** which can be of copper or steel, each terminating in an electrode **5**, are sealed through respective end caps **2** so that the two electrodes **5** project into the chamber **4** from opposite ends and are spaced from each other to form a spark gap. Communicating with the interior of the chamber **4** through one of the end caps **2** is a pipe **7** to which an evacuating pump can be attached and which can be sealed after evacuation.

The electrodes **5** can be surrounded by a metal shield **9** to prevent vapour resulting from the action of the arc from being deposited on the inner wall of the envelope **1**, the shield **9** being formed for example, by an axially split cylindrical member expanding by circlips **10** against an annular abutment **1'** on the inner wall of the envelope **1**. In a modification of the embodiment shown in the drawings the envelope **1** may be of metal and the conductors **1** sealed through insulating bushings in the end caps **2**. In this case the shield **9** may be dispensed with. The electrodes **5** are of composite metallic construction: each of them defines a reference surface **6** and carries a quantity of another metallic material which is characteristic of a lower arcing voltage than is the material of the reference surface **6**. Such a composite metallic construction can conveniently be achieved by forming cavities **8** in the electrode reference surface **6** and filling them with the lower arcing voltage material. For example, the body of the electrode **5** can be of a refractory metal such as molybdenum and the cavities **8** can be filled with a nickel/tin alloy, which may have, for instance, a nickel content of from 70% to 80% the balance being tin. Alloys of nickel, tin and copper in varying proportions have also been found to be suitable, for instance, an alloy consisting of 35% nickel, 15% tin and 50% copper, and an alloy consisting of 56% nickel, 24% tin and 20% copper.

Another form of composite electrode **5** shown in FIG. 3, comprises a metal body **11**, for instance of copper, having a number of cavities **8'** in its front surface and covered on this surface with a conforming layer **12** of molybdenum or other refractory metal which also lines the cavities. The cavities **8'** as thus lined are filled with the nickel/tin alloy already mentioned as indicated at **13**. The forward surfaces **6'** of the refractory metal layer **12** constitute the reference surface previously referred to. The layer **12** may be formed in several ways: for instance it may be electro-plated on to the body **11** or it may be in the form of a pressed plate of appropriate shape suitably secured on to the body **11**, this latter being preformed with its cavities in both cases, or the layer **12** may be constituted by an appropriately shaped pressed plate on to which the body **11** is cast.

A further form of composite electrode (not shown) may present simply a plane surface of refractory metal (which forms the reference surface **6**) coated with a layer of a metallic characteristic of a lower arcing voltage than is the material of the reference surface.

In order to prevent the root of an arc produced between the electrodes **5** from travelling to other parts of the electrode structure, the peripheral side surface of each electrode **5** may be formed with a peripheral cavity (not shown).

Vacuum spark gap devices embodying the invention are eminently suitable for use in conjunction with current limiting resistors as surge divertors in electricity supply systems and for the protection of the conductor insulation, transformer windings or the electrical apparatus of the system. For example in a three-phase electricity supply system a spark gap device according to the invention may be connected between each phase conductor and a neutral point through a common current limiting resistor which can be linear or non-linear. Alternatively a series connection of a spark gap and a current limiting resistor can be connected between each phase conductor and the neutral point.

Furthermore, the accurately determined breakdown voltage enables vacuum spark gap devices to be used in series to provide arrangements having larger breakdown voltages without inaccuracies due to cumulative errors.

Whereas in FIG. 1 the insulating envelope **1** containing the electrodes **5** is shown as having external rain sheds **14**, these may if desired be dispensed with.

What I claim is:

1. A vacuum spark gap device including two electrodes which define a spark gap between them, each said electrode being a composite structure comprising a part which presents a reference surface of a first metallic material and a quantity of a second metallic material exposed to the other electrode at a position adjacent to said surface, the second material being characteristic of a lower arcing voltage than is the first material, and the first material having a higher melting point than the second material.

2. A vacuum spark gap device as claimed in claim 1 including as said second material one which has gettering properties.

3. A vacuum spark gap device including two electrodes which define a spark gap between them, each said electrode being a composite structure comprising a part which presents a reference surface of a first metallic material and a coating of a second metallic material provided on said surface and exposed to the other electrode the second material being characteristic of a lower arcing voltage than is the first material, and the first material having a higher melting point than the second material.

4. A vacuum speak gap device including two electrodes which define a spark gap between them, each said electrode being a composite structure comprising a part which presents a reference of a first metallic material with at least one cavity defined by said surface, and a quantity of a second metallic material contained in said cavity and exposed to the other electrode, the second material being characteristic of a lower arcing voltage than is the first material, and the first material having a higher melting point than the second material.

5. A vacuum spark gap device including two electrodes which define a spark gap between them, each said electrode being a composite structure comprising a reference surface formed by a layer of metallic refractory material and a quantity of another metallic material carried by said surface at a position exposed to the other electrode, this other material having a lower melting point than the refractory material of said layer and being characteristic of a lower arcing voltage than this latter material.

6. A vacuum spark gap device including two electrodes which define a spark gap between them, each said electrode being a composite structure comprising an electrode body of metallic refractory material which presents on a part facing the other electrode a reference surface defining at least one cavity, and a quantity of another metallic material in said cavity, the other material having a lower melting point than the refractory material of the electrode body and being characteristic of a lower arcing voltage than is this latter material.

7. A vacuum spark gap device including two electrodes which define a spark gap between them, each said electrode being a composite structure comprising an electrode body having at least one cavity in a surface facing the other electrode, a plate of a metallic refractory material secured to said surface and shaped to line said cavity, and a quantity of another metallic material contained in the lined cavity, this other material having a lower melting point than the refractory material of said plate and being characteristic of a lower arcing voltage than is this latter material.

8. A vacuum spark gap device including two electrodes which define a spark gap between them, each said electrode being a composite structure comprising an electrode body having at least one cavity in a surface facing the other electrode, an electro-plated layer of metallic refractory material on said surface and lining said cavity, and a quantity of another metallic material contained in the lined cavity, this other material having a lower melting point than the refractory material of said layer and being characteristic of a lower arcing voltage than is this latter material.

No references cited.