United States Patent [19]

Khalid et al.

[11] **3,912,650**

[45] **Oct. 14, 1975**

[54] **HYDRATED ZINC BORATE, DIMETHYL SILICONE RESIN ARC EXTINGUISHING MATERIAL**

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[22] Filed: **May 29, 1973**

[21] Appl. No.: **364,597**

[52] **U.S. Cl.** .... **252/63.5;** 200/144 C; 106/292; 260/37 SB; 252/63.2; 252/63.7

[51] **Int. Cl.**[2] **H01B 3/46**

[58] **Field of Search** .... 423/279, 280; 106/292; 260/37 SB, 46.5; 252/63.5; 200/144 C

[56] **References Cited**

UNITED STATES PATENTS

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[57] **ABSTRACT**

Arc-extinguishing materials are selected in accordance with criteria such as first ionization potential of each of the constituents, carbon content, boiling, sublimation, or decomposition temperature, endothermic character of decomposition, electronegativity of decomposition products, rate of reformation, dimensional and chemical stability, ease of application, cost, toxicity, and coefficient of thermal conductivity.

5 Claims, No Drawings

HYDRATED ZINC BORATE, DIMETHYL SILICONE RESIN ARC EXTINGUISHING MATERIAL

This invention relates to arc-extinguishing materials usable as molding compositions for molding arc shields, arc chute frame components, cases of electrical devices, and the like and also usable in coating form for coating surface portions of a member wholly or partly defining an arc chamber in which separable contacts of an electrical circuit interrupting device are disposed.

Arc interruption requires the establishment of conditions promoting a higher rate of recombination than the rate of ionization. The problem reduces to one of recognizing the basic factors that control these two rates.

One of the factors which should be considered in the selection of arc-extinguishing materials is the first ionization potential of each of the constituents of the material. The first ionization potential of an element is the amount of energy required to remove one electron away to infinity from a neutral atom of that element. For silver, the first ionization potential is 7.54 electron volts, while the first ionization potential for aluminum is 5.98 electron volts. To appreciate the significance of a difference of one electron volt between the first ionization potentials of two elements, consider that the temperature difference between two particles having an energy difference of one electron volt is 7,730° Centigrade.

Another factor which should be considered in the selection of arc-extinguishing materials is electronegativity of decomposition products. This is a measure of the affinity of an atom of an element for electrons. As an arc current approaches zero it would be desirable to have an electronegative gas in the arc chamber that would capture the cooling and slowing electrons. Such electrons would otherwise be accelerated by the rising recovery voltage and cause further ionization and possible reignition.

Yet another factor which should be considered in the selection of arc-extinguishing materials is the boiling sublimation, or decomposition temperature. During the few microseconds preceding and following the passing of the current through zero in an alternating current system, the arc column temperature decreases rapidly until it reaches the temperature of the arc chamber walls, which act as a constant temperature sink. The higher the boiling temperature of the material of the arc chamber walls is, the lower the recombination rates will be.

Endothermic processes have their primary importance at current zero, particularly in the mode of arc interruption wherein a post-arc current flows. Under this latter condition the energy being absorbed in an endothermic process taking place in the arc chamber on a modest scale may approximate the energy being put into the chamber by the post-arc current. This effect, complemented by a favorable boiling temperature, significantly contributes to the success of arc extinction.

If an arc-extinguishing material decomposes to yield free carbon, this carbon may be oxidized to carbon dioxide. The process is exothermic, and its timing is bad, because it is as the arc current approaches zero and the temperature drops and recombination of ions and dissociated molecules starts to take place that the exothermic formation of carbon dioxide occurs. Deposits of

free carbon can also cause tracking and dielectric failure. However, to limit arc-extinguishing materials to those containing no carbon would too severely limit the choice of materials. Moreover, hydrogen has been found to be a desirable component of the gas medium surrounding an arc, especially when an application makes it desirable to force motion of the arc by a transverse magnetic field, and carbon and hydrogen generally occur together. It has been found that the number of carbon atoms as a percentage of the total number of atoms in an arc-extinguishing material should not exceed a value of about 15 percent.

An endothermic process of decomposition is exothermic on formation. Therefore it is desirable to select materials having formulas such that the probability of reformation after decomposition is small. Aluminum oxide (Al_2O_3) and boron oxide (B_2O_3) are materials with such formulas, because the probability of two aluminum or boron atoms colliding simultaneously with three oxygen atoms, or with one molecule and one atom of oxygen, is small. However, aluminum oxide is undesirable as an arc-extinguishing material because the ionization potential of aluminum is low and the boiling temperature of aluminum oxide is too high. In this respect, the present invention is a departure from the prior art as represented by U.S. Pat. Nos. 2,768,264, and 3,071,666 which tout aluminum oxide as a good arc-extinguishing material.

SUMMARY OF CRITERIA

In accordance with the invention, the first ionization potential of each of the constituents of a suitable arc-extinguishing material should be equal to or greater than 7.54 electron volts, which is the first ionization potential of silver. The atomic concentration of carbon in the material should not be greater than about fifteen per cent. The boiling, sublimation, or decomposition temperature of the material should be as low as possible consistent with other requirements, preferably below two thousand degrees Centigrade. Decomposition of the material should be a strongly endothermic process, the more endothermic the better. The products of decomposition of the material should be as electronegative as possible consistent with other requirements. The material should have a formula such that the rate of reformation after decomposition is vanishingly small near the zero point of the alternating current, such as that for B_2O_3 or H_3BO_3. The material should be non-toxic, non-caustic, non-inflammable, easy to process and apply, and dimensionally and chemically stable under operating conditions. Further, it should have good thermal conductivity for an electrically insulating material, preferably greater than 0.001 calories per second per square centimeter per degree Centigrade per centimeter.

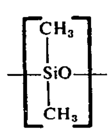
REPRESENTATIVE MATERIALS

In general the oxides, borides, borates, silicates, and the ammonium complexes of the elements having a first ionization potential equal to or greater than that of silver (7.54eV) are suitable arc-extinguishing materials, and so are their hydrated forms. A preferred selection of such elements, with their first ionization potentials shown in parentheses, is tantalum (7.70eV), copper (7.72eV), cobalt (7.86eV), rhenium (7.87eV), iron (7.90eV), tungsten (7.98eV), silicon (8.15eV), boron (8.29eV), palladium (8.30eV), antimony (8.64eV), tellurium (9.01eV), zinc (9.39), and selenium (9.75eV). These substances may also be used as fillers in suitable resins provided that the atomic carbon concentration does not exceed the nominal limit of 15 percent. Silicone resins are suitable. The use of resins becomes mandatory when the filler material cannot be used in its pure form. For example, pure silicon dioxide cannot be used because its boiling temperature is too high, and pure boric acid cannot be used because it is water soluble and therefore dimensionally unstable, but these materials are suitable when used in suitable resins.

Beryllium (9.32eV), arsenic (9.81eV), and mercury (10.43eV) have first ionization potentials higher than that of silver, but these elements are toxic and therefore undesirable. Sulphates, phosphates, nitrates, and halogens are also undesirable as toxic.

Silver, platinum, and gold oxides, borates and silicates, with or without ammonium complexes, would be suitable arc-extinguishing materials except for high cost.

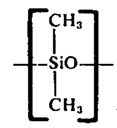
In particular, a material composed of 55.8 per cent by weight Firebrake ZB and 44.2 per cent Sylgard 182 has been found to be a very suitable arc-extinguishing material. Firebrake ZB is made by United States Borax and Chemical Corporation of Los Angeles, Calif., and has a formula $2ZnO.3B_2O_3.3\frac{1}{2}H_2O$. Sylgard 182 is made by Dow Corning Corporation of Midland, Mich. and is a dimethyl silicone resin having a basic monomer represented by the following structural formula:



We claim:

1. An arc-extinguishing material comprising a filler of hydrated zinc borate in a dimethyl silicone resin, the carbon atoms in said resin being no greater than 15 percent of the total number of atoms in said hydrated zinc borate and dimethyl silicone resin combined.

2. An arc-extinguishing material as claimed in claim 1 wherein the filler has the formula $2ZnO.3B_2O_3.3\frac{1}{2}H_2O$ and the resin has a basic monomer represented by the structural formula



3. An arc-extinguishing material as claimed in claim 1 wherein the filler comprises at least 40 percent by weight of the material.

4. An arc-extinguishing material as claimed in claim 1 wherein the filler comprises at least 55 percent by weight of the material.

5. An arc-extinguishing material as claimed in claim 1 wherein the filler comprises about 56 percent by weight of the material.

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