July 10, 1934. T. E. FOULKE 1,965,584

ELECTRIC DISCHARGE DEVICE

Filed July 27, 1929

Fig. 1

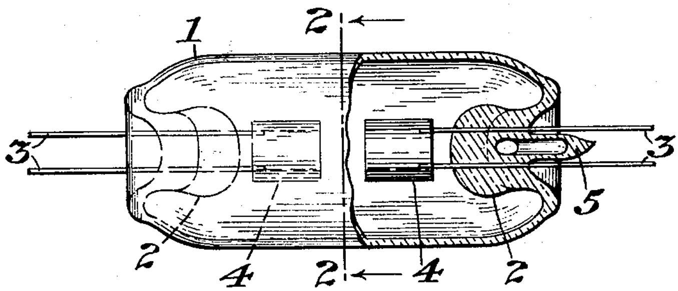
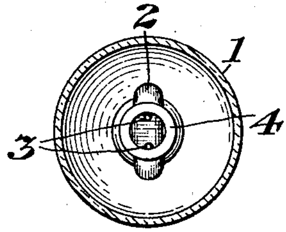


Fig. 2



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ELECTRIC DISCHARGE DEVICE

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11 Claims. (Cl. 250—27.5)

The present invention relates to gaseous electrical discharge devices, and particularly to means for improving the functioning thereof, and to a method of producing the improved devices.

A particular object of the invention is to provide a gaseous electrical discharge device which will have a minimum time lag between application of a potential and initiation of a discharge therein. Another object of my invention is to produce an electrical discharge device which will operate at a relatively low electrode temperature, and which will safely carry large currents with a minimum drop of potential across the device during discharge. Other objects and advantages of my invention will be obvious from the following detailed specification, or from an inspection of the accompanying drawing.

The invention consists in a new and novel product, and in the method of producing the same.

All electric discharge devices have an inherent time lag between the application of a high potential and the initiation of a discharge. This lag has been particularly marked in discharge devices of the gaseous type, with the result that their value for some purposes has been impaired. This has been particularly true in the field of lightning protection, where the adequate protection of associated apparatus requires that a discharge device should discharge to ground before a voltage surge of steep wave front, such as is commonly encountered in this field, has time to build up to dangerous values. I have discovered that by producing a novel coating of low work function, according to a process of my invention, on the electrodes of a gaseous discharge device the time lag thereof is materially reduced below that of a four mil carbon gap, which has heretofore been the fastest discharge device in existance, with the result that my new device protects its associated circuits, when used as a lightning arrester, to a degree which has heretofore been impossible of attainment with discharge devices of the prior art. My new device also has the advantage, in part due to the shape of the electrodes, that the passage of considerable currents does not materially impair its effectiveness. A device constructed in this manner likewise requires considerably less energy to create a discharge, which also contributes to the efficiency of the device as a lightning arrester.

For purposes of illustration I have shown a gaseous discharge device embodying a preferred form of my invention in the accompanying drawing, in which

Fig. 1 is an elevational view, in part section, of a discharge device suitable for use as a lighting arrester, and

Fig. 2 is a sectional view of the same device, taken on the line 2—2 of Fig. 1.

In the drawing, a sealed envelope 1 of glass, fused silica, or other suitable material is formed with oppositely disposed reentrant stems 2, through each of which is sealed a pair of inleads 3. The portion of each of said inleads 3 which extends within the envelope 1 is of dumet, nickel, tungsten, or other suitable material, while the portion which is sealed into the stems 2 is of a material which may be readily fused thereto. Welded to the inner ends of each pair of inleads 3 is a hollow cylindrical electrode 4, the two electrodes 4 being thus supported in substantial alignment with each other with a suitable gap, of say $\frac{3}{16}$ of an inch, therebetween. The electrodes 4 are made of any suitable heat resisting metal, although iron is preferred because of the ease with which it is heated in a high frequency magnetic field to drive occluded gases therefrom. An activating coating of low work function is produced on each of the electrodes 4 in a manner which will hereinafter be set forth in detail. The envelope 1 has a gaseous filling of neon, helium, argon, or other suitable gases or vapors, or combinations thereof, at a pressure which will give a desired breakdown potential.

In the manufacture of the above described device the inleads 3 are sealed into flares in a well known manner to form the stems 2, a tubulation 5 also being included in one of said stems 2. The electrodes 4 are then welded to the inleads 3, after which said electrodes are dipped into, or painted or sprayed with, the activating material. While this material may be any of the alkali or alkaline earth compounds, preferably in the form of azides, oxides, hydroxides or carbonates, I prefer to use those compounds which are reducible to the oxide. Potassium hydroxide, lithium hydroxide, rubidium carbonate and caesium carbonate are examples of compounds which have proved very effective.

For convenience the ensuing procedure will be given with respect to electrodes which have been coated with a saturated water solution of potassium hydroxide, although it will be understood that the same process, with minor changes which will be obvious to one skilled in the art, is applicable to the treatment of electrodes coated with any of the compounds in the class set forth above. These coated electrodes 4 are first thoroughly dried in an oven, the temperature of which is preferably kept below the point at which the coating compound rapidly combines with components of the air, 100° C. being the maximum desirable in the case of potassium hydroxide. The stem assemblies are then sealed into the tubular envelope 1, care being taken to keep the temperature of the parts as low as possible consistent with the proper working of the glass, in order to avoid heating of the electrodes 4 above 100° C. for the reason set forth above. The tubulation 5 is then connected to a vacuum pump, and the envelope 1 completely evacuated. While this vacuum is maintained the device is enclosed in an oven and baked for five or ten minutes at 350° C. in order to drive out occluded gases and vapors from the walls of the envelope 1. After the oven is removed, but with the vacuum still being maintained, the electrodes are raised by means of a high frequency inductive field to a bright red heat, corresponding to a temperature of approximately 800° C., in order to drive out occluded gases and vapors therefrom. This heating also causes a reduction of a portion of the potassium hydroxide coating on the electrodes 4 to the oxide, with a small amount thereof reduced still further to metallic potassium. The remainder of the hydroxide coating is sublimed from the electrodes 4 onto the walls of the envelope 1. In addition to being an active getter, this sublimed film on the envelope 1 is an extremely good indication that the proper reduction to the oxide is taking place on the electrodes 4, since if the coating has been heated above the critical temperature of approximately 100° C. while still in contact with air, this sublimed film is not produced to any appreciable extent. The time lag characteristic of a device in which the coating has been overheated in contact with air, while considerably better than that of discharge devices of the prior art, is not as good as that of devices prepared in the preferred manner. It is believed that this is due to the transformation of the potassium hydroxide at the higher temperature into other potassium compounds which reduce largely to the metallic form with only a trace of oxide. This would explain the difference in result, since it is well known that a coating of alkali or alkaline earth metal has a higher work function than a coating of the same metal intimately mixed with the oxide thereof. In any case, the presence of a sublimed film is an indication of optimum electrode condition. The envelope 1 is then filled with a suitable gaseous atmosphere, the pressure being determined by the breakdown potential desired and the tubulation 5 is then sealed-off.

By way of example, a mixture comprising 75% neon and 25% helium at a pressure of 45 m. m. of mercury will give a breakdown potential of 200–300 volts in a device having the physical characteristics set forth above.

In the case of coatings of other alkali or alkaline compounds the process is very similar to that described in connection with potassium hydroxide. The temperatures at which the various steps are performed will vary, of course, within the obvious limits determined by the characteristics of the compound used. And in case the compound chosen is one which does not sublime this indication of the attainment of the desired result will not be produced.

It has been found that the configuration of electrodes coated in the above manner is of importance, the coated tubular electrodes used in the preferred form of my device being particularly effective. It is believed that the space charge within the tubular electrodes is neutralized, the result being that there is an extremely low drop in potential, of the order of 10 volts, at the cathode. This effect, which is markedly enhanced by the alkaline coating, results in a minimum of heat production within the device, which in turn results in the operation of the electrodes at low temperatures, even while a heavy discharge is maintained within the device. Since destruction of the electrodes by undue heating is thereby minimized it is apparent that the protection afforded to associated apparatus by the device of my invention is correspondingly increased.

While I have described my device as particularly advantageous for lightning protection it is obvious that it is of more general use, and that devices constructed according to my invention may be used as indicator lamps, potential regulators, and for other analogous purposes. It will also be understood that various changes may be made in the process or in the separate steps thereof without modifying or changing the essential features of the product produced and that various changes and substitutions may be made in the product within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed is:

1. A lightning arrester comprising an envelope containing a gaseous atmosphere, and electrodes sealed therein, each of said electrodes being coated with the oxide of an alkali metal.

2. A lightning arrester comprising an envelope containing a gaseous atmosphere, electrodes sealed therein, one of said electrodes being coated with an alkali metal intermixed with the oxide thereof.

3. A lightning arrester comprising the combination of an envelope containing a gaseous atmosphere, and electrodes sealed therein, said electrodes being coated with potassium intermixed with potassium oxide.

4. A lightning arrester comprising the combination of an envelope containing a gaseous atmosphere, tubular electrodes sealed therein, said electrodes being of substantially the same diameter, and a coating of the oxide of an alkali metal on said electrodes.

5. A lightning arrester comprising the combination of an envelope containing a gaseous atmosphere, tubular electrodes sealed therein, said electrodes being of substantially the same diameter, and a coating of a metal having a low work function intermixed with the oxide thereof on said electrodes.

6. A lightning arrester comprising the combination of an envelope containing a gaseous atmosphere, electrodes sealed therein, each of said electrodes being tubular, and a coating of potassium intermixed with potassium oxide on said electrodes.

7. The method of producing an electrode for a gaseous discharge device which comprises coating said electrode with potassium hydroxide, maintaining said coating at a temperature below 100° C. so long as it is in contact with air, and then heating said electrode in a vacuum to reduce said hydroxide partly to the oxide and partly to the metallic form.

8. The method of producing an electrode for a gaseous discharge device which comprises coat-

ing said electrode with potassium hydroxide, maintaining the temperature of said electrode below 100° C. while it is in contact with air, and then heating said electrode to 800° C. in a vacuum.

9. A lightning arrester comprising an envelope containing a gaseous atmosphere, and electrodes sealed therein, each of said electrodes having a coating thereon of an alkali metal intermixed with the oxide thereof, said oxide constituting the greater portion of said coating.

10. The method of producing an electrode for an electric gaseous discharge device which comprises coating an electrode with an oxygen containing compound of an alkali metal, maintaining said coating during the period that it is in contact with air at a temperature below that at which chemical change occurs therein and then heating said coating in a vacuum to reduce it partly to the oxide and partly to the alkali metal.

11. An electrode for an electric discharge device comprising a tubular body having a coating of an alkali metal intermixed with the oxide thereof on its inner surface, the internal diameter of said body being less than the diameter at which the cathode fall thereto equals the fall to a plane electrode having a like surface.

TED E. FOULKE.