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ELECTRON DISCHARGE DEVICE EMPLOYING SECONDARY ELECTRON EMISSION AND METHOD OF MAKING SAME

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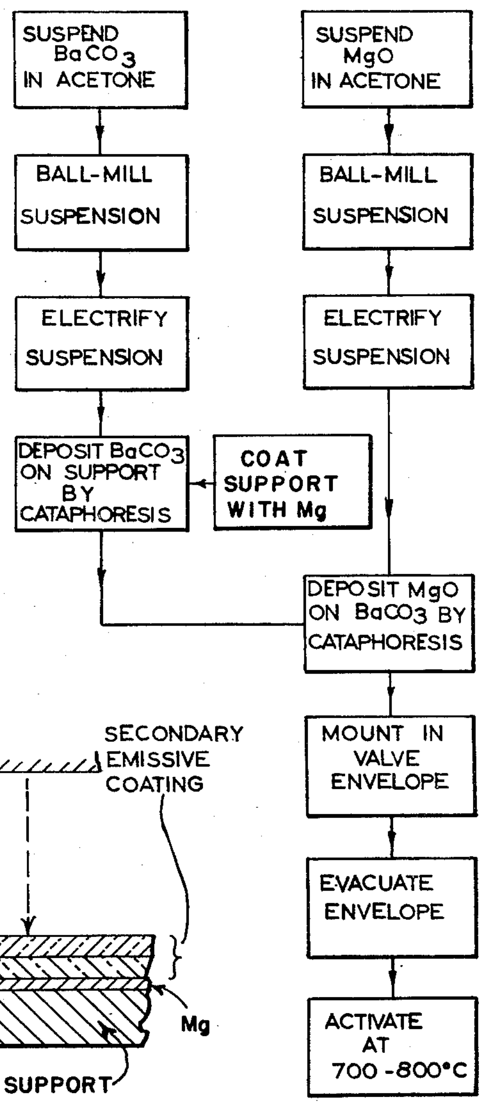

FIG. 1

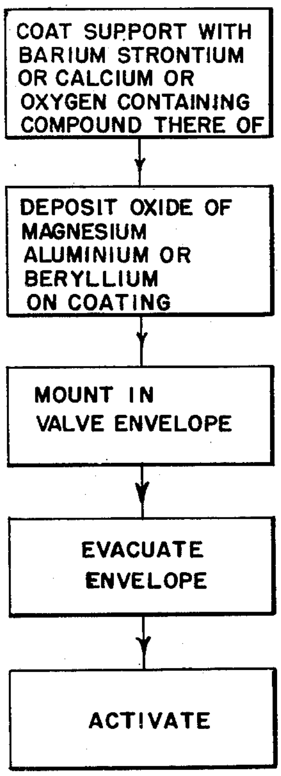

FIG. 2

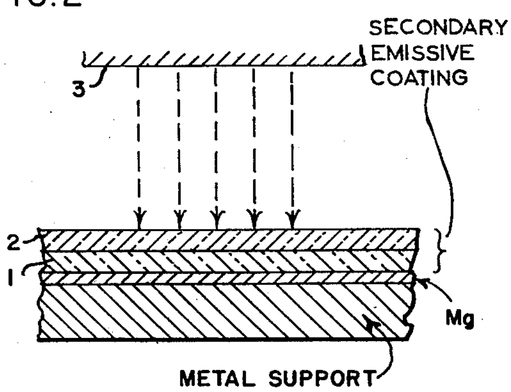

FIG. 3

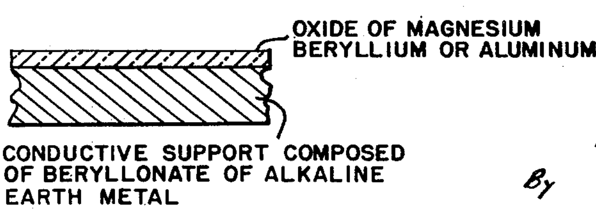

FIG. 4

Inventor
ALBERT HORACE ATHERTON
By Ralph E. Atherton
Attorney

United States Patent Office

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ELECTRON DISCHARGE DEVICE EMPLOYING SECONDARY ELECTRON EMISSION AND METHOD OF MAKING SAME

Albert Horace Atherton, Ealing, London, England, assignor to Electric & Musical Industries Limited, Hayes, England, a British company

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9 Claims. (Cl. 313—103)

This invention relates to electron discharge devices employing secondary electron emission, and to electrodes for use therein.

Various proposals have heretofore been made for the construction of amplifying valves in which a primary beam of electrons is caused to impinge on a secondary-electron emitting electrode which emits a larger number of secondary-electrons than there are impinging primary electrons. Such valves are particularly suitable for amplification at high frequencies and over a wide range of frequencies, the primary electrons emitted from a thermionic cathode being controlled in intensity by the application of the signals to be amplified to a control electrode, and the amplified signals being set up across a load impedance connected to an electrode which collects the emitted secondary-electrons.

In the United States Patent 2,585,534 there is described a secondary-electron-emitting electrode suitable for use in such a thermionic amplifying valve, the electrode comprising a conductive support to which is applied a coating of the oxides of magnesium and barium in the form of an intimate mixture of said oxides. The barium oxide is provided in the coating to increase the conductivity of the coating under operating conditions, with a view to making possible the use of relatively thick coating of secondary-electron-emitting material and thus producing a valve having a satisfactorily long life even under operating conditions such that decomposition of the coating on the secondary-electron-emitting electrode occurs as a result of bombardment by primary electrons. However, mixing of the barium oxide with magnesium oxide is thought to be disadvantageous from the point of view of obtaining a large secondary emission ratio.

The object of the present invention is to provide an improved electron discharge device incorporating a secondary-electron-emitting electrode, mainly with a view to reducing the above-described disadvantage.

According to the present invention there is provided an electron discharge device having a secondary electron emitting electrode and a means for bombarding said electrode with electrons to cause the emission of secondary electrons from said electrode, said electrode comprising a conductive support having applied to said support an inner coating of a refractory oxide selected from the group consisting of barium oxide, strontium oxide and calcium oxide, and an outer coating of another refractory oxide applied to said inner coating.

The outer coating of refractory oxide preferably consists of magnesium oxide, but the outer coating may alternatively consist wholly or partly of one or more other refractory oxides (other than an alkaline earth metal oxide), for example aluminium oxide and beryllium oxide. Moreover, it is to be understood that the term "alkaline earth metal" is intended to include only barium, strontium and calcium, and preferably the substance on which the outer coating is deposited contains barium oxide.

With a device according to the present invention, during activation of the secondary electron emitting electrode and subsequently during operation of the device, gradual reduction of the inner coating occurs to yield the metal barium, strontium or calcium as the case may be. The metal can migrate to the outer refractory outside coating and promote conductivity therein although the surface from which, on operation of the device, the emission of secondary electrons actually occurs will be composed mainly of the refractory oxide forming the outer coating. Moreover, it is thought that the free metal further improves the performance of the electrode by the formation of an adsorbed layer of the metal on the surface of the conductive support, thereby decreasing internal work function of the electrode, that is to say, the energy required to cause an electron to pass from the conductive support into the coating thereon.

The present invention further provides an electron discharge device incorporating a secondary electron emitting electrode comprising a conductive support and a coating of the oxide of a metal selected from the group consisting of magnesium, beryllium and aluminium on said support, said support consisting of a metal body containing a beryllonate of an alkaline earth metal, whereby said support constitutes a source from which during operation of said device said alkaline earth metal diffuses to said coating.

In order that the invention may be clearly understood and readily carried into effect, the invention will be described with reference to the accompanying drawings, in which:

Figure 1 is a flow diagram of a preferred method of manufacturing an electron discharge device according to the present invention,

Figure 2 is a more general flow diagram illustrating the invention,

Figure 3 is a fragmentary cross-sectional view of a secondary electron emitting electrode and of means for bombarding the same with electrons, and

Figure 4 illustrates a modification of Figure 3.

The present invention is especially applicable to thermionic amplifying valves, and in preparing a secondary electron-emitting electrode for a thermionic amplifying valve according to the example of the present invention illustrated in Fig. 1, a suitable metallic strip or tube is provided as an electrode support, being formed for example from nickel. The support is carefully cleaned and, if of nickel, may thereafter be provided with a thin superficial protective coating of magnesium as described in the United States Patent No. 2,585,534.

Barium carbonate powder is added to acetone containing a small quantity of nitro-cellulose, the acetone being free from water, and the suspension of the barium carbonate in acetone is ball-milled and then electrified by shaking. Thereafter the barium is deposited on the electrode support by the well known process of cataphoresis, the support being made cathodic in the electrified suspension which is preferably stirred during the cataphoresis. The deposition on the support is continued until a layer of barium carbonate weighing about 0.001 gm. per square centimeter of coated surface is obtained. Thereafter an outer layer of megnesium oxide is deposited on the layer of barium carbonate by a similar process, the deposition again being continued until a layer of magnesium oxide weighing about 0.001 gm. per square centimeter of coated surface is obtained.

The coated electrode support is then assembled in the envelope of the thermionic amplifying valve, which may be of the construction described in the co-pending United States Patent No. 2,553,997. Thereafter the envelope is evacuated and to complete the formation of the electrode the coated electrode support is degassed, and activated by heating to a temperature of between about 700° C.

and 900° C. for some minutes. During the activation the barium carbonate is reduced to barium oxide with the formation of some free barium, the carbon dioxide being removed by pumping in known manner. Formation of further free barium probably occurs during the operation of the valve, under normal operating conditions the secondary-electron-emitting electrode attaining a temperature of about 500° C or thereabouts.

The secondary-electron-emitting electrode may alternatively be manufactured by evaporating a thin film of barium on to the electrode support in vacuo, thereafter evaporating a thin film of magnesium in vacuo on top of the barium film and then exposing the support with the barium and megnesium films thereon to oxygen to oxidise the barium and megnesium films, thus forming an outer coating of megnesium oxide on top of a coating of barium oxide. The coated electrode support is then mounted in the envelope of the thermionic valve and subsequently degassed and activated as described in the previous paragraph. The thickness of the layers formed by this alternative method may be less than 5 microns (about 2×10^{-4} inches).

The electrode support may alternatively be coated by spraying successive layers thereon. For example, a mixture of barium and strontium carbonates such as utilised in the manufacture of coated thermionic cathodes, and containing equal quantities by weight of the two carbonates, may be sprayed on to the electrode support to form the inner layer. The spraying may be continued until the deposited layer has a thickness about 5×10^{-4} inches. Thereafter a layer of magnesium oxide of about the same thickness may be deposited on top of the mixed carbonate layer by spraying or by some other method. The support coated in this manner can then be mounted in the thermionic valve envelope and subsequently processed in the above-described manner.

It will of course be appreciated that the two layers need not be formed by the same method, and they need not necessarily be of about the same thickness.

Figure 2 is a flow diagram of the method of manufacturing a secondary electron emitting electrode according to the present invention, taking account of the alternatives herein mentioned. In Figure 3 the resultant electrode is shown having an inner coating **1** of one or more of the oxides of barium, strontium and calcium, and an outer coating **2** of one or more of the oxides of magnesium, aluminium and beryllium. Reference **3** represents a thermionic cathode for producing electrons which bombard the secondary electron emitting electrode to cause the emission of secondary electrons from the latter electrode. If the electrode support consists of a metal body containing an alkaline earth metal beryllonate, the electrode support may be formed as described in the Patent No. 2,185,410. An electrode having a support containing a beryllonate of alkaline earth metal is represented in Fig. 4.

What I claim is:

1. An electron discharge device incorporating a secondary-electron-emitting electrode comprising a conductive support, and a coating of the oxide of a metal selected from the group consisting of magnesium, beryllium and aluminium on said support, said support consisting of a metal body containing a beryllonate of an alkaline earth metal, whereby said support constitutes a source from which during operation of said device said alkaline earth metal diffuses to said coating.

2. An electron discharge device having a secondary electron emitting electrode and means for bombarding said electrode with electrons to cause the emission of secondary electrons from said electrode, said electrode comprising a conductive support, a coating of a mixture of barium oxide and strontium oxide on said support to constitute a source of the metals barium and strontium, and a coating of magnesium oxide on said first-mentioned coating.

3. An electron discharge device according to claim 2, said coating of magnesium oxide having a deposit of the order of 0.001 gm. per square centimetre of coating.

4. A method of producing an amplifying electron discharge device having a secondary electron emitting electrode, comprising the steps of providing a conductive electrode support carrying metal selected from the group consisting of barium, strontium, and calcium, depositing refractory oxide selected from the group consisting of magnesium oxide, aluminium oxide and beryllium oxide on said support, mounting the coated support in said discharge device as a secondary electron emitting electrode, evacuating the device and thereafter activating said electrode by heating to a temperature in the range from about 700° C. to about 900° C. to produce some of said selected metal at the surface of said conductive support, whereby the internal work function of the electrode is reduced.

5. A method of producing an amplifying electron discharge device having a secondary electron emitting electrode, comprising the steps of providing a conductive support with a coating of an oxygen containing compound of metal selected from the group consisting of barium, strontium and calcium, providing on said first coating an outer coating of refractory oxide selected from the group consisting of magnesium oxide, aluminium oxide and beryllium oxide, mounting the coated support in said device as a secondary electron emitting electrode, evacuating the device, and thereafter activating said electrode by heating to produce some of the selected metal at the surface of said conductive support, whereby the internal work function of the electrode is reduced.

6. A method of producing an amplifying electron discharge device having a secondary electron emitting electrode, comprising the steps of providing a conductive support wtih a coating of an oxygen containing compound of metal selected from the group consisting of barium, strontium and calcium, providing on said first coating an outer coating of refractory oxide selected from the group consisting of magnesium oxide, aluminium oxide and beryllium oxide, mounting the coated support in said device as a secondary electron emitting electrode, evacuating the device, and thereafter activating said electrode by heating to a temperature in the range from about 700° C. to about 900° C. to produce some of the selected metal at the surface of said conductive support, whereby the internal work function of the electrode is reduced.

7. A method of producing an amplifying electron discharge device having a secondary electron emitting electrode, comprising the steps of providing a conductive support with a coating of oxygen-containing compounds of barium and strontium, providing on said first coating an outer coating of refractory oxide selected from the group consisting of magnesium oxide, aluminium oxide and beryllium oxide to a thickness of about 0.001 gm. per square centimetre of said coating, mounting the coated support in said device as a secondary electron emitting electrode, evacuating the device, and thereafter activating said electrode by heating to a temperature in the range from about 700° C. to about 900° C. to produce some barium and strontium metal at the surface of said conductive support, whereby the internal work function of the electrode is reduced.

8. An electron discharge device having a secondary electron emitting electrode and a means for bombarding said electrode with electrons to cause the emission of secondary electrons from said electrodes, said electrode comprising a conductive support having applied to said support an inner coating of a refractory oxide selected from the group consisting of barium oxide, strontium oxide and calcium oxide, and an outer coating of another refractory oxide applied to said inner coating.

9. An electron discharge device having a secondary electron emitting electrode and a means for bombarding said electrode with electrons to cause the emission of secondary electrons from said electrode, said electrode

comprising a conductive support having applied to said support an inner coating containing barium oxide and an outer coating of magnesium oxide applied to said inner coating.

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