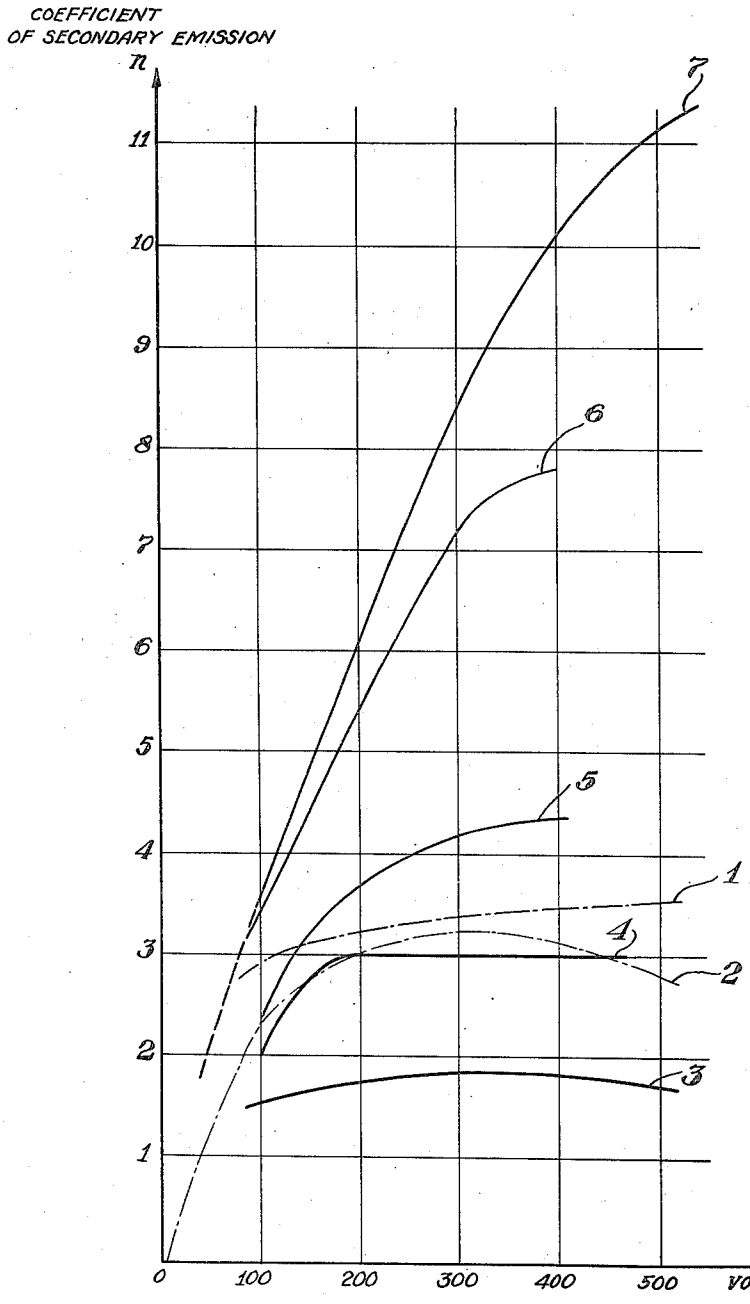
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VACUUM TUBE ELECTRODE

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VACUUM TUBE ELECTRODE

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1

This invention relates generally to improvements in vacuum tube electrodes and in particular is concerned with the manufacture of vacuum tube electrodes having high secondary electron emission power.

In accordance with this invention, electrodes are fabricated from certain readily available alloys and treated whereby they then exhibit greatly increased secondary electron emission power—that is, secondary emission greater than is obtainable with presently known electrodes having surface layers containing, for example, compounds of caesium, silver or the like.

Pursuant to this invention, the electrodes are activated, i. e., their secondary emission power is increased, by a thermal treatment which causes a substantial change in the appearance of the electrode surface and, by virtue of a preferential migration phenomenon, is believed to change the distribution therein of the component elements, particularly the distribution of copper or an equivalent heavy element when it is present in the alloy. Although the theory of operation of this phenomenon is not now wholly clear, practical experience indicates that a relationship may exist between this phenomenon and the electrode activation which is reflected in much greater secondary emission exhibited by such electrodes compared with that of electrodes made of an alloy not so treated, or made according to prior art with surface layers containing compounds of caesium, silver or the like.

In accordance with this invention, electrodes having these desired properties of high secondary emission are prepared by processing alloys which contain one or more light metals of the group consisting of aluminum magnesium and beryllium, and which preferably but not necessarily also contain a metal of the copper family. For example, an alloy which is especially suitable for use in the practice of the present invention is a Duralumin alloy having the approximate composition: aluminum 95%, copper 4%, manganese 0.5%, magnesium 0.5%, and traces of iron. However, it has been found that the principles of the present invention can be utilized in treatment of alloys irrespective of their composition provided they include appreciable proportions of the elements above mentioned.

In connection with this invention, it was found that electrodes made from alloys of the type above mentioned, when examined after cleaning and polishing, and prior to thermal treatment, exhibit a coefficient of secondary emission only very

2

slightly superior to those of electrodes made from the component pure metals, being in general in the neighborhood of 2.5 to 3 for primary electron speeds of the order of 300 volts. By the term coefficient of secondary emission is meant the ratio of the number of secondary electrons emitted by the electrode to the number of primary electrons striking the electrode. It also was found that this secondary emission coefficient of untreated electrodes does not change appreciably when the speed of impact of the primary electrons is changed provided that it is at least 100 volts. It was further found that if an electrode made of one of these alloys is heated at a relatively low temperature in an oxidizing atmosphere (pure oxygen or air), the coefficient of secondary emission initially decreases, although the slope of the curve representing variations of secondary emission as a function of the primary electron speed remains substantially the same as that of an untreated electrode.

However, it is now found according to the present invention that if the temperature at which the electrode is heated in the oxidizing medium is materially increased, the appearance of the electrode surface changes, become dull, and the coefficient of secondary emission of the electrode begins to increase without appreciable change in the slope of the curve representing secondary emission variation as a function of the impact speed of the primary electrons. As the temperature of treatment is further increased, the electrode surface appears to become granular, and the metal begins to swell or puff. At this point, the coefficient of secondary emission increases very rapidly, reaching, for example, a value of 10 for an impact speed of 400 volts; and at the same time the curve of secondary emission variation as a function of primary speed changes its slope, passing the maximum, which is generally very peaked, for speeds in the neighborhood of 500 to 550 volts.

A characteristic of these electrodes thus obtained is that the coefficient of secondary emission remains the same even if, after preparation and mounting in a vacuum tube, the electrodes are operated at a temperature which may reach 400° C.

In accordance with this invention, thermal treatment of the electrodes to cause activation as described is performed before they are mounted in the tubes in which they are to be used and preferably consists of uniformly heating the electrodes at progressively higher temperatures in

pure oxygen or in air. Heating may be caused by electric resistance or high frequency induction, or if desired by employing a continuous or discontinuous discharge between the electrodes to be treated and auxiliary electrodes, or it may be effected by use of a heated stove through which a current of oxygen or pure air is circulated.

The end point of the activation treatment is determined by examining the electrodes periodically to note the changes in appearance mentioned above. It is particularly to be noticed that the swelling of the electrode surface initially proceeds very rapidly, and the time to stop heating is when the electrode surface becomes very considerably swollen, as also occurs when too high a temperature is applied, and after such treatment the electrodes merely exhibit a coefficient of secondary emission of approximately the same order as that of an untreated electrode.

After the heat treatment to cause activation as above described, the electrodes may be installed in a discharge tube and degassed in the usual manner by heating under vacuum to 350–400° C. for about three-quarters of an hour. This degassing operation, as is well known, is desirable if a hard or high vacuum is to be necessary in the tube wherein the electrodes are to be used. It does not affect the secondary emission coefficient of the processed electrodes.

The accompanying drawing illustrates typical curves representing the relationship of secondary emission coefficient to primary electron speeds. The curves numbered 1 and 2 indicate the variation of secondary emission coefficient as a function of primary electron speed when the tested electrode was made of a Duralumin alloy which was not subjected to the activation treatment according to this invention. The other curves numbered 3 through 7, represent corresponding characteristics of electrodes that have been subjected to heat treatment when progressively higher temperatures were employed. The low temperature treatment illustrated by the curves numbered 3, 4 and 5 did not cause material activation of the secondary emission properties above the approximate level characteristic of typical untreated electrodes whereas treatment at higher temperatures resulted in an extraordinary degree of activation as represented by the curves numbered 6 and 7.

Although the electrodes prepared according to this invention exhibit unusually large secondary emission coefficients, which may be as high as 10–15, it is of interest that no inertia has been observed in the secondary emission phenomenon, i. e., when the primary electron stream is interrupted, secondary emission immediately ceases, which indicates that here the secondary emission is a normal, not an abnormal phenomenon, in contrast to the experimental studies described by Malter in "The Physical Review," 5, 48 et seq. (1936).

It is to be understood that in this specification and in the accompanying claims where the appearance of a processed electrode is described as being slightly granular, it is meant that the electrode has been processed under conditions such that a polished surface thereof during the processing becomes dull and lacking in luster and that after further processing the surface becomes matte in appearance due to the formation of minute pits or bumps upon the surface. It is this last condition that constitutes the end-point of the activation process herein described.

To facilitate an understanding of the present invention, a specific example of how the invention may be practiced will now be described, but it is clearly to be understood that this example is provided by way of illustration, not by way of limitation of the invention.

Example

An alloy is prepared having the following composition based on weight:

	Percent
Aluminum	95
Copper	4
Manganese	0.5
Magnesium	0.5

A piece of this alloy was fabricated into an electrode by the usual rolling, stamping, cleaning and polishing operations and the electrode thus obtained was mounted on a support and placed in a chamber containing oxygen for heat treatment. The electrode was then heated at progressively elevated temperatures until the surface of the electrode appeared slightly granular, at which time the treatment was immediately discontinued and the electrode was removed from the chamber. When tested for secondary emission power, this electrode was found to exhibit an unusually high ratio of electrons emitted from the electrode compared with the number of electrons impinging thereupon.

Having thus described the present invention, what it is desired to secure by Letters Patent is:

1. In a process for the manufacture of a vacuum tube electrode having an abnormally high secondary emission coefficient, the improvements that comprise selecting an alloy containing a predominant proportion of a metal selected from the class consisting of aluminum, magnesium and beryllium; forming an electrode from said selected alloy; and heating said electrode in the presence of oxygen and at a temperature such that a polished surface of the alloy would become slightly granular in appearance.

2. In a process for the manufacture of a vacuum tube electrode having an abnormally high secondary emission characteristic, the improvements that comprise selecting a predominantly aluminum alloy, forming an electrode from said selected alloy, and heating said electrode in the presence of oxygen and at a temperature such that a polished surface of the alloy would become slightly granular in appearance.

3. In a process for the manufacture of a vacuum tube electrode having an abnormally high secondary emission characteristic, the improvements that comprise selecting a predominantly beryllium alloy, forming an electrode from said selected alloy, and heating said electrode in the presence of oxygen and at a temperature such that a polished surface of the alloy would become slightly granular in appearance.

4. In a process for the manufacture of a vacuum tube electrode having an abnormally high secondary emission characteristic, the improvements that comprise selecting a predominantly magnesium alloy, forming an electrode from said selected alloy, and heating said electrode in the presence of oxygen and at a temperature such that a polished surface of the alloy would become slightly granular in appearance.

5. A vacuum tube electrode having an abnormally high secondary emission characteristic, formed of an alloy containing a predominant proportion of a metal selected from the class con-

sisting of aluminum, beryllium and magnesium which has been heated in an oxygen-containing atmosphere at a temperature such that a polished surface of the alloy would assume a slightly granular appearance.

6. An electrode as claimed in claim 5 in which the alloy selected has substantially the following composition: aluminum about 95%, copper about 4%, the balance consisting of magnesium and manganese.

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