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ELECTRIC DISCHARGE TUBE HAVING AT LEAST ONE NON-EMITTING ELECTRODE WHICH CONSISTS AT LEAST SUPERFICIALLY OF NICKEL

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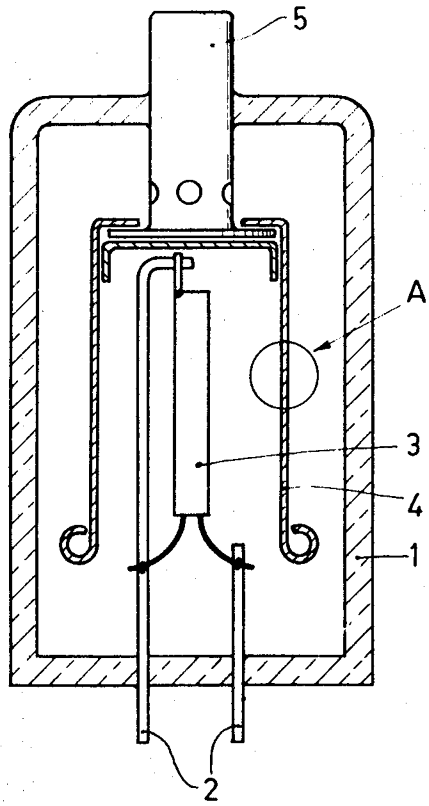

fig.1

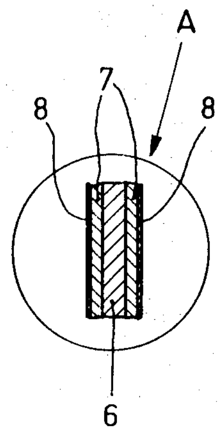

fig.2

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ELECTRIC DISCHARGE TUBE HAVING AT LEAST ONE NON-EMITTING ELECTRODE WHICH CONSISTS AT LEAST SUPERFICIALLY OF NICKEL

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ABSTRACT OF THE DISCLOSURE

A method of manufacturing an electric discharge tube by first coating non-emitting electrodes such as an anode with a layer of nickel and then a layer of gold, and then heating the electrode during pumping to a degassing temperature about 780° C. The emission-suppressing characteristics of the non-emitting electrodes are maintained even though the gold dissolves in the nickel.

The invention relates to an electric discharge tube having at least one non-emitting electrode which consists at least superficially of nickel. The invention relates particularly to a rectifier tube for high voltages which is provided with an anode consisting of nickel-plated iron.

It is known that nickel having emitting oxides shows a good primary emission upon heating. A cathode therefore usually consists of a nickel support for the emitter layer.

"Cold" electrodes, for example, screens and anodes, are often manufactured from nickel-plated iron, since this material is not only cheap but can also be readily machined. This is of particular importance for anodes for very high voltages, since in this case the edges have to be beaded to avoid sputtering phenomena. Materials such as molybdenum present great difficulties upon beading due to their hardness.

A drawback of the use of materials which consist superficially of nickel, for example, nickel-plated iron, however, is that, if during the manufacture or during operation, emitting material of the cathode is deposited on said material, the cold electrode starts emitting which may give rise to breakdown of the tube which has for its result that the cathode melts and short-circuit occurs which may have expensive consequences in particular operated with high voltages.

It is known from U.S. patent specification 3,070,721 to provide a layer of gold on a copper anode which forms a part of the wall of the tube so as to suppress anode-emission. In order to avoid the formation of an alloy of the gold with the copper, as a result of which the gold layer becomes inoperative, a nickel intermediate layer is provided by which diffusion of the gold in the copper is avoided. The layer of gold must hence be maintained as such.

In British patent specification 698,675 gold is provided on a copper anode and alloyed with the copper so as to avoid the giving off of the gas of the anode upon electron bombardment.

In British patent specification 646,015 a readily conducting layer of gold is provided on a nickel-plated iron anode with a view to the "skin effect." For this purpose also the gold layer must hence be maintained as such.

So it is known per se that gold suppresses the emission. However, it is always ensured that the layer of gold as such is maintained. It is generally expected that an alloy of the gold with the underlying material will destroy the emission-suppressing effect.

Since gold dissolves in nickel or forms an alloy with it comparatively rapidly at a temperature of 600° C. already, it was necessary upon degassing the known tubes to ensure that the temperature of the gold-plated electrode remains far below the said temperature. However, degassing then lasts long. The conventional degassing temperature lies at approximately 820 to 850° C. At such a high temperature the layer of gold fully disappears in the nickel layer and it is found that the emission-suppressing effect of the layer of gold is lost.

When a metal, for example, molybdenum, is chosen as a substrate for the layer of gold, the gold does not dissolve, it is true, but the danger exists that if the electrode, during operation, obtains a high temperature, gold evaporates and the cathode is poisoned.

It has been found that the said difficulties can be fully avoided while maintaining the advantages namely the emission suppression, the non-evaporation of the gold and the easy machinability of the electrode material—by using the methd according to the invention, in which an electrode which is not destined for electron emission and which consists at least superficially of nickel and of which at least the surface facing the cathode is coated with a layer of gold in a manner known per se, is heated during evacuation and degassing of the tube, at a temperature of maximally 800° C. so that the gold fully dissolves in the nickel, it is true, but the emission-suppressing effect thereof is maintained.

It has been found in experiments that at the conventional degassing temperature, in which the electrode is heated to approximately 825° C., the gold disappears in the nickel so rapidly and so deeply that the emission-suppressing effect is strongly reduced and, upon degassing at a temperature of 850° C., is substantially entirely lost. After evacuating at 780° on the contrary, said effect was found to be fully present although in this case also the layer of gold has dissolved entirely in the nickel. The electrode after heating at 780° C., has a bright nickel color in which no gold is visible. The presence of the gold can be demonstrated only with special auxiliary means, for example, spectral analysis.

In order that the invention may be readily carried into effect, one embodiment thereof will now be described in greater detail, by way of example, with reference to the accompanying drawing, in which

FIG. 1 is a longitudinal cross-sectional view through the rectifier tube for high voltages provided with an anode according to the invention, and

FIG. 2 shows a part A of the anode wall prior to degassing of the tube.

Reference numeral **1** in the figure is a glass envelope, **2** denotes the supply pins for the filament and cathode **3**.

The anode **4** consists of nickel-plated iron **6**, a layer of gold **8** being provided on the layer of nickel **7** (FIG. 2). The gold **8** is dissolved in the nickel **7** by degassing at 780° C. for 100 to 110 seconds. The nickel layer **7** has a thickness of 16μ, while the original gold layer **8** was thinner than 1μ. The gold layer **8** therefore disappears entirely in the nickel layer. Nevertheless the emission-suppressing effect of the gold is found to be maintained entirely if degassing has taken place at a temperature of maximally 800° C. The anode **4** is secured in the wall **1** of the tube by means of a tubular current supply member **5** consisting of an oxidized chromium-iron alloy.

The supply conductor **5** may previously be secured to the anode **4**. A large number of anodes are coated in a drum in known manner with a layer of gold, the thickness of which is smaller than 1μ, by means of a bath which contains potassium-gold cyanide and ammonia, which is obtained commercially under the registered trade name "Atomex." It has been found that the oxidized surface of the supply conductor **5** is not covered with gold so that cleaning thereof is not necessary.

It has been found in measurements that in a high voltage diode having an anode consisting of nickel-plated iron, which anode is heated at 760° C. by means of high frequency heating, and in which an opposite voltage of 200 volt is applied between the cathode and the anode (anode negative), an anode emission current of 25 ma. occurs if the anode has not been treated with gold. In the case of a gold-plated anode which was degassed at 780° C. and in which the gold had dissolved in the nickel or had formed an alloy with it, the anode-emission current under the same circumstances was found to be only a few micro-amperes and usually smaller than 1μa. It has also been found that gold does not evaporate from the surface of the anode, so that no cathode poisoning occurs.

The temperature at which the gold is dissolved in the nickel is found to be critical above 800° C. From so-called short-circuit experiments, in which a rectifier for 25 to 30 kv. and provided with a diode test tube is short-circuited until the anode of the test tube has reached a temperature of 600° C. after which the short circuit is removed, it was found that in the case of anodes consisting of nickel-plated iron not treated with gold the anode emission is so strong that the cathode melts. Reject percentage 100. In a large number of gold-plated anodes, the following results were obtained dependent upon the temperature at which the gold was dissolved in the anode nickel layer; gold dissolved at 780° C.; 800° C.; 815° C.; 850° C. Rejects in short circuit test: 0%; 0%; 30%; 100%.

With a view to inaccuracies in the temperature measurement during manufacture, 800° C. hence is the maximally permissible degassing temperature. It has been found that upon degassing at 780° C. the conventional duration of 100 to 110 seconds can be maintained which time is often used upon degassing at 825° C. For applying the invention, the cycle time of the mill constructed for a pump temperature of 825° C. need consequently not be varied.

Although a single example has been described, the invention may also be applied in other cases in which undesired emission of electrodes not destined for electron emission, or other nickel surfaces has to be suppressed, for example, in the concentration plates in electron beam pentodes, in anodes for X-ray tubes, and the like.

What is claimed is:

1. A method of manufacturing an electric discharge tube comprising coating at least one non-emitting electrode with a layer of nickel, coating the nickel layer of said non-emitting electrode with a layer of gold, assembling emitting and non-emitting electrodes within said electric discharge tube and evacuating and degassing said electric discharge tube, said evacuating and degassing comprising heating said non-emitting electrode at a temperature at which occluded gases are released from said electrode and not greater than 800° C. to fully dissolve the gold in said nickel layer, thereby maintaining the emission-suppressing effect of said non-emitting electrode.

2. A method of manufacturing an electric discharge tube as claimed in claim **1** wherein coating the nickel layer comprises this step of coating thereon a layer of gold having a thickness not greater than 1μ and heating said non-emitting electrode to dissolve the gold in said nickel layer comprises heating to a temperature of 780° C. for a time interval between 100 and 110 seconds.

3. A method of manufacturing an electric discharge tube as claimed in claim **1** wherein coating at least one non-emitting electrode comprises coating with a layer of nickel having a thickness at least ten times greater than the thickness of the layer of gold.

4. A method of manufacturing an electric discharge tube as claimed in claim **1** wherein coating the nickel layer comprises gold-plating in a bath essentially consisting of potassium-gold-cyanide and ammonia.

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