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CARBONIZED NONEMISSIVE ELECTRODE

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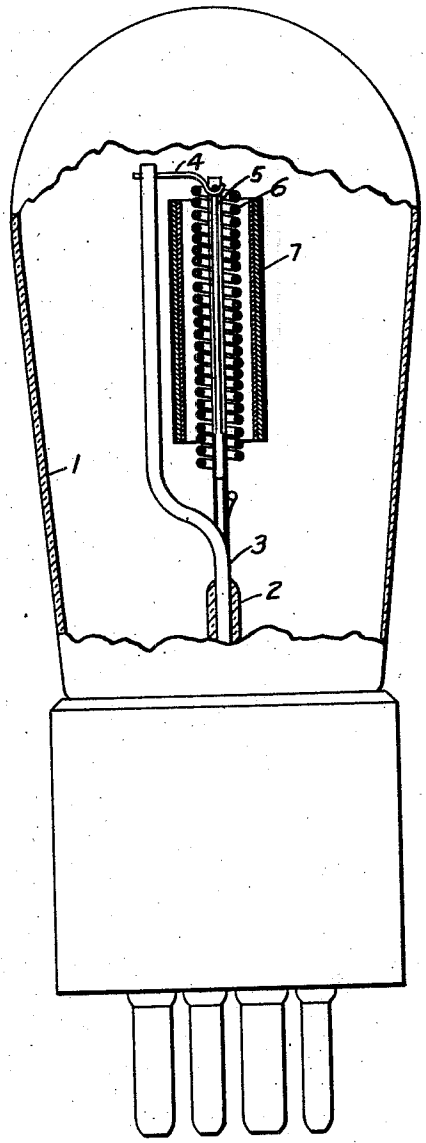

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UNITED STATES PATENT OFFICE

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CARBONIZED NONEMISSIVE ELECTRODE

Application filed February 21, 1927. Serial No. 170,063.

My invention relates to electron-discharge devices and particularly to such devices having one electrode intended to act as a source of electrons and another electrode not intended to become such a source of electrons.

One object of my invention is to provide means to prevent an electrode intended to be, at all times, non-emissive from acting as a source of electrons even when its temperature is considerably raised or when it is subject to considerable voltage stress.

Another object of my invention is to provide an electron tube containing thermionically emissive oxides with electrodes having surfaces which destroy the thermionically emissive property of oxides depositing upon them.

Another object of my invention is to provide electron tubes with metal anodes having surfaces having a high coefficient of thermal radiation.

Other objects of my invention will become apparent from the following description.

In electron tubes having thermionically emissive cathodes, particularly cathodes comprising oxides of the alkali-earth metals, there is a tendency for the cathode material to volatilize and deposit upon the anodes or other electrodes of which the intended function, in operation, is that they shall not emit electrons.

Since tubes in which the power output is considerable have anodes which run at rather elevated temperatures, the result of such deposition is that the anodes fail to perform their expected function and become emitters of electrons. In cases, for example, of diode tubes acting as rectifiers, this results in the short circuiting of the A. C. line, with disastrous consequences.

I have found that, by treatment of the anodes of such electron tubes to carbonize their surfaces the tendency to become emitters of electrons is practically obviated. Data have been secured which demonstrate that the phenomenon is not capable of ready explanation on the basis of known chemical laws. Whatever may be the cause of the results obtained, the discovery has proved of great value in improving the voltage and current rating at which electron tubes may be operated.

Another improvement upon electron tubes of the prior art has resulted from my process of carbonizing the electrodes. The power output of such tubes has been limited, in the past, by the ability of their anodes to dissipate heat. It is desirable that the electrodes in high-vacuum tubes shall be of metal since metals may be freed from occluded gases to an extent which is impossible, for example, in the case of graphite. Tubes having metallic electrodes can, in fact, operate at the very high vacuum desired in present day practice for much longer periods than would be possible with any type of porous electrode. Metallic electrodes, however, normally have bright surfaces.

My process of carbonizing results in a blackening of the surface, thereby greatly increasing its ability to radiate heat and, consequently, decreasing the temperature at which it will operate at a given current. As a result of substituting my carbonized electrodes for ordinary metallic electrodes of the same dimensions, the capacity of standard rectifier tubes was found to be increased 35%.

With the foregoing principles and objects in mind, my invention may be more readily understood by reference to the accompanying drawing which shows a three-electrode tube of a usual type in which my invention has been embodied.

Referring to the drawing a vacuum-tight container 1 has a press 2 through which inleading wires 3 are sealed, in a manner well known in the art. One of the inleading wires extends parallel to the axis of the tube and is provided with an arm 4 which supports a hot-cathode filament 5 of the well known type comprising a base filament covered with a coating of barium oxide and strontium oxide. Others of the aforesaid inleading wires support a grid electrode 6, which may be formed, in a manner well known in the art, by winding a helix of molybdenum between vertical support arms. Surrounding the grid electrode 6 is a cylindrical plate electrode 7 which is supported from still others of the aforesaid inleading wires in a manner too well known

to require extended description. The anode 7, and, if desired, the grid electrode 6, are provided with the carbonized coating, which is a feature of my invention, in the manner now to be described.

Electrodes on which I practice my process may be of nickel, tungsten, or some other suitable metal. They may be used as main anodes or as control electrodes, or otherwise, wherever an electrode which shall be free from thermionic emission is desired in electron tubes. The electrodes to be carbonized should, of course, be mechanically clean to begin with. They may be given a preliminary treatment by heating in vacuo for an extended period to free them from occluded gases.

Having been properly prepared, the process of carbonizing the surface consists in heating the electrodes at a temperature of approximately 800° to 1000° C. dependent upon the metal utilized in an atmosphere of acetylene for about 1 to 2 hours in a furnace from which the air is excluded.

While I have found acetylene to be effective as a carbonizing agent, I have also found that illuminating gas may be used with excellent results, and it is my belief that many other gaseous carbon compounds, the identity of which will be evident to skilled chemists, will serve the required purposes.

As a result of such treatment at high temperature in an acetylene atmosphere, the surface of the electrode becomes carbonized in a very permanent form, probably by formation of a carbide of the metal.

After the completion of the carbonizing treatment, the electrodes may be annealed by leaving them in the furnace and slowly reducing the temperature over a period of several hours. They may thereafter be sealed into containing vessels provided with proper cooperating electrodes as already described in connection with the drawing herein. The cathode may, for example, consist of a tungsten or nickel filament coated with a mixture of the oxides of barium and strontium. Back-emission has been found to be of particularly low value in tubes using a cathode comprising barium and strontium oxides on the base filament described in application Serial No. 144,911 of E. F. Lowry filed October 28, 1926 and assigned to the Westinghouse Electric & Mfg. Co. The electron tubes, produced in accordance with the foregoing, are then subjected to the usual process of exhaust, which has become standardized in the art and is too well-known to require extended description here.

The non-emitting electrodes produced by my process may be used as anodes for hot-cathode rectifiers or may become anode or control electrodes, either or both, in an electron tube having one or more grids. For example, the performance of a tube having a shielded grid as well as a control grid is greatly improved when electrodes carbonized in accordance with my invention are substitutes for ordinary metallic grids.

By the use of electron tubes provided with my carbonized electrodes, the line voltage on which rectifiers of given dimensions may be operated can be increased by reason of the absence of danger of thermionic emission from the anodes, with consequent back discharge.

The cathode temperature and, consequently, the saturation current of the tube may be increased, since the consequences of volatilization of the cathode material are much less serious. Simultaneously, an anode of given dimensions runs at a lower temperature at full load by reason of the increased thermal emissivity of its surface. That, of itself, lessens the danger of the occurence of back discharge, and, furthermore, lessens deterioration of the vacuum of the tube by gases evolved in consequence of the heating of the anode. The current and voltage rating of the tube may be increased in consequence of each of these effects.

In the case of three or four electrode tubes, corresponding advantages are obtained from the decreased tendency of the anode and control electrodes to thermionically emit and also from their increased thermal emissivity consequent upon the carbonization.

While I have shown one way of carbonizing the various elements of electron tubes, various other methods will be evident to persons of skill in the art, and I desire that my claims shall not be limited to the precise process which I have described.

It is also obvious that other metals than nickel or tungsten may constitute the inert electrodes and that other thermionic emitters than barium and strontium oxides may constitute the cathodes.

It is also evident that the increased thermal emissivity which results from the blackening of the metal electrodes is useful, independently of whether cathode material deposits on the anode or not and, furthermore, that it is not limited to carbonization as a process of producing the blackened surface.

While, therefore, I have here described my invention in accordance with the patent statutes to illustrate the construction and operation thereof, it is apparent that various changes and modifications may be made in the precise process I describe without departing from the spirit of my invention. I desire, therefore, that only such limitations shall be imposed thereon as are indicated by the appended claims or demanded by the prior art.

I claim as my invention:—

1. A high vacuum electrical discharge tube comprising a cathode comprising a thermionically emissive oxide and an electrode co-

operating therewith comprising a composite of carbon and a metal.

2. A high vacuum electrical discharge tube comprising a cathode comprising a thermionically emissive oxide and a metallic electrode cooperating therewith comprising a surface layer including a composite of carbon and a metal.

3. An electrical discharge tube comprising a cathode comprising an oxide of a metal in the alkali-earth group and an electrode cooperating therewith comprising a composite of carbon and a metal.

4. An electrical discharge tube comprising a cathode comprising an oxide of a metal in the alkali-earth group and an electrode cooperating therewith comprising a composite of carbon and nickel.

5. An electrical discharge tube comprising, as a cathode, a filament comprising an oxide of a metal in the alkali-earth group and an electrode cooperating therewith comprising a composite of carbon and a metal.

6. An electrical discharge tube comprising an emissive cathode subject to vaporization and an anode member and a control electrode member each cooperating therewith, said members comprising a composite of carbon and a metal.

7. An electrical discharge tube comprising an emissive cathode subject to vaporization and an electrode cooperating therewith comprising a composite of carbon and a metal.

In testimony whereof, I have hereunto subscribed my name this 14th day of February, 1927.

CHARLES B. UPP.