Aug. 9, 1932. E. G. WIDELL 1,870,306

CATHODE FOR ELECTRON DISCHARGE DEVICES

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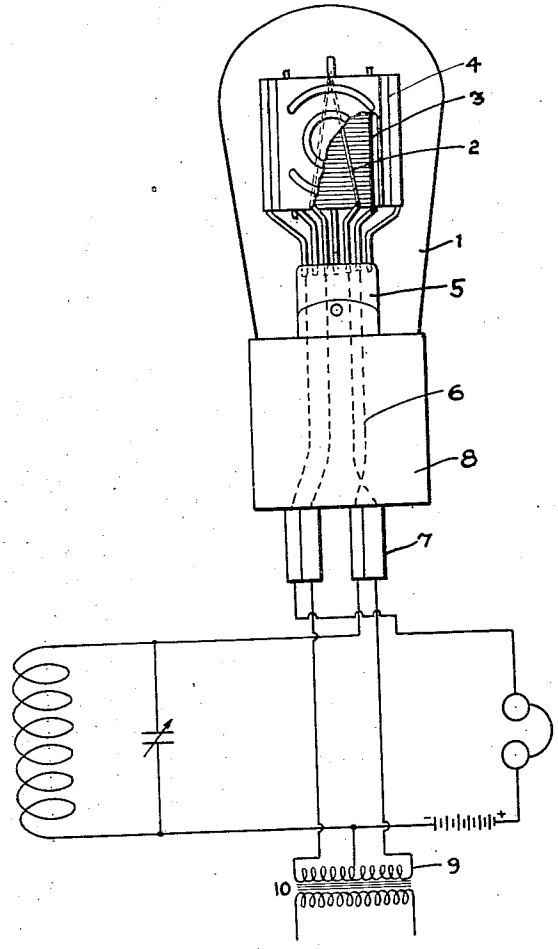



Fig. 1.

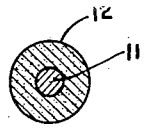



Fig. 2.

INVENTOR
EMIL G. WIDELL

BY

ATTORNEY

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# UNITED STATES PATENT OFFICE

EMIL GIDEON WIDELL, OF BLOOMFIELD, NEW JERSEY, ASSIGNOR TO WESTINGHOUSE LAMP COMPANY, A CORPORATION OF PENNSYLVANIA

## CATHODE FOR ELECTRON DISCHARGE DEVICES

Application filed May 27, 1926. Serial No. 112,180.

This invention relates to a cathode for an electron discharge device and more particularly to a cathode adapted to be heated by alternating current without the drawbacks normally incident to the employment of such heating currents.

One of the objects of the present invention is to produce an electron-emitting cathode for an electron discharge device which may be heated from an alternating current source and in which the usual alternating current hum will be eliminated.

Another object is to produce an electron-emitting cathode operable on an alternating current heating source which will have a low power consumption.

Another object is to produce a cathode for an electron discharge device adapted to be heated by alternating current in which the troublesome effects caused by the changing magnetic field produced by the passage of the alternating current through the cathode will be reduced to a negligible degree.

Another object is to provide a cathode operable on alternating current which is simple in construction and effective in operation and which will have a long life and uniform operating characteristics.

Other objects and advantages will hereinafter appear.

Heretofore great difficulty has been experienced in utilizing alternating current for heating the cathode of an electron discharge device for use in radio receiving apparatus due to the hum which is produced in the receiving apparatus by the alternating current and which seriously interferes with the reception.

This alternating current hum is due to several causes, first among which may be mentioned the capacity effect between the grid and the filament, due to the periodic or alternating current potential variations along the cathode. This capacity effect causes a fluctuating charge on the grid which is amplified in the plate circuit.

Another cause of the alternating current hum is the variation in temperature of the cathode during the alternations of the heating current and the consequent fluctuations in the electron emission from the cathode.

A still further cause of this noise incident to the use of alternating current for heating the filament is due to the constantly changing magnetic field surrounding the filament set up by a passage of current therethrough. This field exerts an irregular effect on the emitted electrons, causing them to travel in various and constantly changed directions and periodically repulsing and accelerating the electron stream in such manner as to produce an irregular and pulsating current.

It has been proposed heretofore, to construct a cathode adapted to be heated by alternating current, of a heavy metal core, the function of which is to serve as a heat reservoir to obtain a more uniform temperature of the cathode and thus eliminate the variations in the electron emission, due to fluctuating temperature. Such filaments, however, require large heating currents, due to their large cross section, the minimum current flow obtainable with such cathodes being about 1½ amperes. This heavy current induces a strong magnetic field about the cathode which is constantly fluctuating and which largely overcomes the beneficial effect of the uniform heating of the cathode. Moreover, in employing thick heavy metallic filaments of this nature there is a large loss of power at the ends of the filament, known as end losses due to the rapid conduction of heat from the filament by the leading-in and support wires.

Another method which has been proposed to overcome the difficulty incident to using alternating current as a heating source is to employ an auxiliary heater for heating the cathode by induction and radiation. One method which has been suggested is to employ a refractory core having a heating coil or electrical resistor therein, said core having a metal sheath coated with the oxides of the alkaline earth metals. Such a cathode is of complicated construction and expensive to manufacture. Moreover, it requires a high heating current usually about 1½ amperes and due to the large diameter thereof, there is an appreciable capacity effect between the

cathode and the other electrodes which, to some extent, affects the obtaining of clear reception.

The present invention aims to avoid all of the above mentioned difficulties or to reduce the effects thereof to a negligible degree so that the hum incident to the use of alternating current for heating the cathode is not detectable in the output circuit.

In accordance with my invention I construct a cathode having a metal core of small cross section and consequently small current consumption and coat the same with an extremely heavy layer of a non-metallic refractory material of poor heat conductivity but high electron emissivity. Such a material may consist of a mixture of the oxides of the alkaline earth metals such as barium and strontium or a mixture of such oxides with other refractory oxides such as magnesia and alumina. I have found that when a sufficiently heavy layer of alkaline earth oxides, for instance, are applied to a small platinum or platinum-iridium wire that the oxide coating acts as an extremely efficient medium for storing up the heat supplied by the metallic core and maintaining the temperature of the cathode substantially uniform throughout the alterations in the heating current so that the emission obtained from the filament is substantially uniform. Preferably, a coating of the oxides of barium and strontium is applied and sufficient thickness to constitute about 10 milligrams of the coating material per square centimeter of surface area of the cathode. This weight of coating is many times that employed in the ordinary construction of oxide coated cathode. Good results are obtainable with from 3 to 4 milligrams of the coating per square centimeter but in order to insure the elimination of the 120 cycle hum obtained from the 60 cycle alternating current heating source I prefer to employ the heavier coating.

The coating may be applied in the form of a carbonate of the alkaline earth metal although I do not desire to be limited to any particular method of producing such heavy coating. One method which may be employed for producing the cathode is that described in application Serial No. 587,270 of Duncan MacRae, filed Sept. 11, 1922, Patent No. 1,812,103 entitled Electron emitting cathode and method of making and assigned to the Westinghouse Lamp Company. Briefly, such method consists in applying a number of coatings of the carbonates of barium and strontium from an aqueous suspension thereof, the cathode being heated after each application of the coating material in carbon dioxide at a sufficiently high temperature to fuse the coating thereto.

Another method is that disclosed in co-pending application Serial No. 108,235, Widell et al., filed May 11, 1926 entitled Oxide coated cathodes and method of making the same, and assigned to the Westinghouse Lamp Company. This method consists in suspending the carbonates of the alkaline earth metals in a solution of a cellulose ester dissolved in alcohol and ether and baking the coatings on at about 200° C. to drive out the volatile solvent. This method is preferable to the former in some respects since it permits heavier coatings being obtained at each application of the carbonate, thereby reducing somewhat the number of coatings required to produce the requisite thickness on the metal core.

After the carbonate coating of the desired thickness has been formed, the filament is mounted in a discharge device in the usual manner and heated preferably during exhaustion to decompose the carbonate to the oxide, the liberated gases being withdrawn by the exhaust system.

I preferably employ a metallic core which is operable at about ½ ampere to produce the requisite heat for obtaining emission from the oxide coating. However, smaller metallic cores may be employed if desired. It has been determined, however, that when a metallic core consuming about ½ ampere is employed that the magnetic field produced by such current does not appreciably effect the electron stream so as to produce irregular current flow in the output circuit. Instead of making the coating entirely of the oxides of barium and strontium, it may be composed in part of other inert refractory non-conducting material such as the oxides of magnesium or aluminum either mixed with the electron-emiting material or applied as separate layers. The inert oxides do not interfere with the electron emission from the alkaline earth oxides and serve as an extremely efficient heat reservoir for maintaining the temperature of the cathode uniform.

End losses are substantially eliminated when employing a thin metallic core since the loss of heat by conduction through the thin core to the lead wires is negligible as compared to such loss in heavy metallic cores. The capacity effect between the cathode and the other electrodes is also small when employing thin metal cores for the cathode and the alternating current hum caused by this capacity effect is thereby lessened.

Reference is made to the accompanying drawing in which:

Fig. 1 illustrates a conventional type of three-electrode tube employing the cathode described herein and circuit arrangement therefor; and,

Fig. 2 is a cross sectional view of the cathode.

The tube shown in Fig. 1 comprises the usual envelope 1 containing a cathode 2 constructed in accordance with the foregoing description, a grid 3 and an anode or plate

electrode 4. These electrodes are supported from the press 5 in the usual manner and are provided with current conductors 6 secured to contact posts 7 carried by the base 8 of the tube.

The cathode is heated to an electron-emitting temperature by any convenient source of alternating current, as the secondary 9 of a transformer 10. The circuit arrangement shown is of the conventional type of detector circuit.

The cathode consists of a thin metallic core 11 of suitable metal, such as platinum or platinum-iridium, and a heavy layer 12 of a refractory electron-emitting oxide such as an oxide of an alkaline earth metal. It will be appreciated that the view shown in Fig. 2 is enlarged many times, the core preferably being of such diameter that it consumes not more than one-half ampere of current.

It will be noted that by the present invention all of the material causes of humming due to the alternating current heating source are eliminated or reduced. The irregular effect of the alternating heating current is eliminated by providing a heat reservoir of considerable capacity and low thermal conductivity. The hum caused by the magnetic field surrounding the cathode is reduced to a negligible amount by employing a metallic core which requires a small heating current to raise it to the required temperature and the hum due to capacity between the grid and filament is reduced by employing a small amount of metal in the cathode.

It is obvious, of course, that many changes may be made in the construction of this cathode without departing from this invention and I do not desire to be limited to the exact details described, except as defined in the following claims.

What is claimed is:

1. A cathode for an electron discharge device comprising an electrically conducting core member and a coating of a thermionically active material on the outer surface of said core member, with a substantial portion of said surface having on each square centimeter thereof a coating of about three to ten milligrams of the thermionically active material.

2. A cathode for an electron discharge device comprising an electrically conducting core member and a coating of a thermionically active material on the outer surface of said core member, with a substantial portion of said surface having on each square centimeter thereof a coating of about three to ten milligrams of the thermionically active material, said metallic core operable at no greater than about one-half ampere to produce the requisite heat for obtaining electron emission from said coating.

3. An electron emitting cathode composed of a core and a coating containing an alkaline earth metal oxide, the weight of said coating being about 10 milligrams per square centimeter of coated surface.

In testimony whereof, I have hereunto subscribed my name this 25th day of May 1926.

EMIL GIDEON WIDELL.