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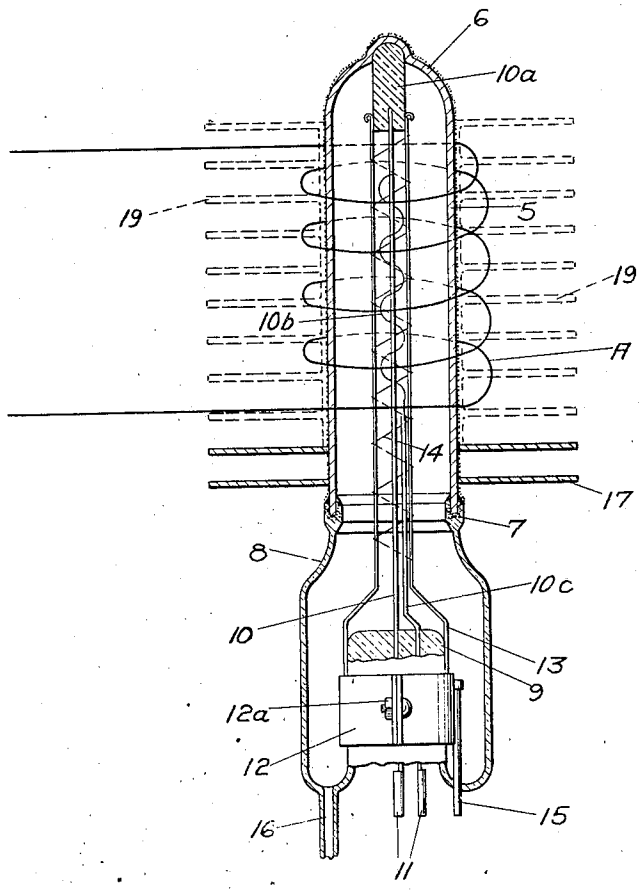
VACUUM TUBE MAKING

Filed March 29, 1924



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VACUUM-TUBE MAKING

Application filed March 29, 1924. Serial No. 702,818.

This invention relates to the construction and manufacture of electron or vacuum tubes, especially those constructed for the handling or control of relatively large currents, such for instance, as the so-called power tubes used in radio broadcasting stations, and relates particularly to tubes of the type shown in my co-pending application Serial No. 698,925, filed March 13, 1924.

In my said application, I have described a tube having an air cooled exterior anode. In said application, it is pointed out that, in making tubes having a metal envelope which is also the anode of the tube, it is necessary to heat the metal anode to a high degree of temperature for a sustained period of time to successfully de-gasify the tube, and that this is done largely by passing a current through the filament of the tube, whereby the anode is heated by radiation and electronic bombardment. This process is entirely satisfactory where a high temperature filament is used.

It is well known in the art that certain substances, when applied to a filament, give a high electron emission at relatively low temperatures. This means that, when such substance is applied to the filament of an electron tube, high emissivity is obtained at comparatively low temperatures. This is made use of in small tubes, that is, the so-called dry cell tubes.

However, little success has been attained in applying this knowledge to power tubes, although the desirability of tubes having a high electron discharge with a low watt-hour consumption of current has been appreciated, especially for portable transmitting stations, and transmitting apparatus of small water craft. One of the chief difficulties in the way of using a low temperature filament has been due to the difficulty of satisfactorily de-gasifying power tubes having the low temperature filament, a problem which is not difficult to overcome in the small tubes.

The present invention has for its object to provide a power tube having a filament capable of giving high electron emission with a low filament current, together with a method of treating the filament in the tube to initially bring it to a proper state of activation, that is, a state where high emissivity may be obtained without immediate disintegration of the filament.

A further object of the invention is to provide a tube having an exterior air cooled anode which comprises also the shell of the tube and a low temperature cathode.

A further object of the invention is to provide a method of de-gasifying a tube having a low temperature cathode.

The invention may be readily understood by reference to the accompanying drawing, in which the figure represents a longitudinal section through a tube of the type to which the invention is applicable.

In the drawing, 5 designates a metal tube having a closed end 6. This tube is preferably made of nickel or some other metal which is passive to deteriorating oxidation at relatively high temperatures.

Sealed to the open end of the tube, at 7, is a glass base or seal 8. This seal is developed by incorporating into the glass at the point of contact with the metal, an oxide, such as copper oxide, as described in my said copending application, and forming no part of the present invention.

Inside the glass seal or base is a cylindrical mounting or stem 9 which supports a filament rod 10 that extends longitudinally of the tube, its upper end being received in a quartz block 10*a* centered in the closed upper end of the tube. Having its upper end attached to this post, near the top thereof, is a filament or cathode 10*b* that spirals around the post 10 out of contact therewith. The lower end of this filament connects to the top of a short post or connector 10*c* well up inside the tube, so that the filament does not extend down as far as the seal 7. Both posts 10 and 10*c* extend through the glass, being sealed therein, and may have connectors 11 on the outer ends thereof.

Surrounding the stem 9 is a split band 12 having its ends clamped together at 12*a* to frictionally retain the band on the stem. This band carries a plurality of heavy wire supports 13, as described in my said application, suitably bent to shape, these wires

extending longitudinally of the tube and having their upper ends tied together about the quartz block 10*a*. A continuous wire 14 coiled around posts 13, outside the filament, forms the grid of the tube.

At 15 is a conductor that passes through the glass and connects with the metal ring 12, thus providing a connector for the grid. At 16 is designated the tubular extension where the tube is connected with the pump, and where it is sealed off.

Initially secured to the metal shell 5 are one or more heat radiating fins or disks 17, which are in close proximity to the seal. I have shown two such fins in full lines on the drawings. More could be provided, but as their presence before de-gasifying the tube would interfere with satisfactory heating to drive out the gas and condition the filament, as hereinafter described, only the two disks 17 are preferably provided at first to protect the seal 7. Should it be desired, after the tube is evacuated, to have additional radiating surfaces, a sleeve 18, shown in dotted lines in the drawing, having fins 19, may be slipped over the completed metal shell after the tube has been completed.

The filament 10*b* is formed of molybdenum wire which has been alternately dipped in a thorium nitrate solution and heated to about 700 degrees C., until a fairly heavy coating has been formed on the wire. Such a filament, after being properly conditioned, as hereinafter described, will, when heated to a point approximating a barely visible glow, produce an extremely high electron emission.

Other than the dipping of the filament, the present novel process begins after the tube has been assembled to the point shown in the drawings, where the tube is ready to be evacuated.

The tube is connected to the pump in the usual manner at 16, and the greatest part of the gas in the tube is removed. Then, with the tube still on the pump, an oven is lowered around the tube and the tube is baked in the oven, at a temperature of about 450 degrees C., for a sustained period of time, an hour probably being sufficient. This drives most of the gas from out of the glass base and a large amount of it out of the metal anode.

Then, an electric heating coil A is lowered around the metal anode of the tube only, and a current passed therethrough to heat the anode, the temperature of the anode being raised by this means to about 800 or 1000 degrees C. This operation is continued for about one hour, and during that period the oven is retained around the entire tube, whereby the glass will be kept from absorbing any of the gas liberated at this stage. This gas is, of course, removed by the pump. During this operation, the anode is heated well beyond any temperature that will be reached in the subsequent operation of the tube.

The heating of the anode with the external coil A also causes the cathode or filament to be heated by radiation from the anode. This external application of heat to the cathode, in a high vacuum, drives out gases from the cathode and conditions the coating to withstand subsequent energization, and brings it to a state where most favorable electron emission for a sustained period of time can be obtained.

Now that the tube is extremely hard, and the anode heated far above any temperature that will subsequently be reached in the later operation of the tube, and the filament well conditioned or activated, a current is passed through the filament which is well below the normal operating current. This is done with the external coil and oven around the tube. Gradually, the filament current is increased until, eventually, the normal operating current is applied. A very minute quantity of gas may be liberated by the passage of currents through the filament, but this is immediately removed by the pump. The normal operating voltage is reached gradually in order to avoid any initial excessive straining of the filament.

When the normal operating current is applied to the filament, and with the external anode still heated, a positive potential is applied to the anode, and the anode subjected to electronic bombardment for a period of time. This bombardment, taking place with the anode at a temperature well above any temperature which it will subsequently reach in later operation, effectively removes all traces of gas that might otherwise be liberated in the later operation of the tube.

In order to more effectively bombard the plate, and de-gasify the grid, which, like the filament, is initially heated by radiation from the anode, the tube may be connected to oscillate for a while. Then it may be further cleared up by sparking high voltage currents through it. After this, it may be again operated with a normal filament voltage and a positive potential on the plate, then sealed off, and removed from the pump.

In this manner, a tube having a low temperature cathode is provided, which tube is extremely free of gas. The filament, being conditioned or activated in the tube and in a relatively high vacuum, gives very satisfactory results. Were a current to be passed through the filament before the filament had been conditioned in the tube in this manner, or before the tube is hard, it would not be so satisfactory or so durable, and would have to be operated at higher temperatures, and would be subject to disintegration, while the tube itself would not be stable.

Fins 17 protect the seal from being over-

heated during the exhaustion of the tube, while fins 19 are applied after the tube is completed.

Although I have described a particular filament construction, I do not confine myself to the use of molybdenum as a base or thorium nitrate as a coating, though both are preferred.

I claim as my invention:

1. The method of preparing a high emitting low temperature cathode in electron tubes having metal shells with glass seals, which consists in assembling into the tube a cathode having a low temperature high electron emitting coating thereon, connecting the assembled tube with a pump, baking the entire tube to partially de-gasify it at a moderately high temperature but below the melting point of glass, then raising the temperature of the metal shell of the tube to a glowing temperature while maintaining the glass seal hot but below its melting temperature, the tube remaining in connection with the pump, and the cathode being heated in a vacuum by the radiation of heat from the shell, whereby the cathode is conditioned for service and de-gasified in a vacuum and in place in the tube.

2. The method of manufacturing electron tubes having a metal envelope forming the anode of the tube, a glass seal for the envelope and a coated high emission low temperature cathode which consists in assembling the tube with a coated cathode therein, exhausting the tube, and, during the process of exhaustion, baking the entire tube and subjecting the envelope by an external heating means to a temperature considerably above that to which the glass is subjected and ranging in proximity to 1000 degrees C., the cathode also being heated at this time by radiation from the envelope, then, while continuing the exhausting operation and with the continued application of heat to the tube sufficient to keep the envelope above its subsequent normal operating temperature, subjecting the anode to electron bombardment from the filament, and subsequently sealing off the tube.

3. The method of conditioning electron tubes having metal envelopes and glass seals and provided with low temperature high emission cathodes, in which cathode there is a metal base and a coating, which consists in exhausting the tube with a pump, then, while the exhausting operation is being continued, heating the metal envelope of the tube and the cathode from an external heating means to a temperature above the melting point of glass, while preventing the heat in the metal envelope from being conducted from said metal envelope to the glass seal in a sufficient amount to injure the said seal, then connecting positive current to the metal envelope to bombard the tube, subsequently oscillating the tube while maintaining the tube connected to the pump, whereby the tube is degasified and conditioned for service.

4. The method of conditioning for service electron tubes having metal envelopes and glass seals, and provided with cathodes having a high emission low temperature coating which consists in assembling the coated cathode in the tube, exhausting the tube, and while the exhausting operation is being continued heating the tube and heating the cathode from an external heating means, and raising the temperature of the cathode thereby to about 800 degrees C. or above, and the temperature of the metal envelope above the melting point of glass and at the same time maintaining the temperature of the glass seal below the melting point of glass, then bombarding the tube by applying current to the metal envelope, subsequently passing high potential sparking current through the tube while connected to the pump, whereby the tube is degasified and conditioned for service.

5. The method of conditioning for service an electron tube provided with a cathode having a high emission low temperature coating and a metal anode sealed to a glass envelope which consists in assembling the coated cathode in the tube, exhausting the tube, and while the exhausting operation is being continued heating the tube and heating the cathode from an external heating means, raising the temperature of the anode above the melting point of the glass and at the same time maintaining the temperature of the glass seal below the melting point of glass, and gradually raising the temperature of the cathode to about 800 degrees C. or above, then bombarding the tube by passing a current through the cathode while the tube remains heated, subsequently causing the tube to oscillate, then again bombarding the tube and finally sealing the same off for normal use.

6. The method of manufacturing electron tubes having a metal envelope forming the anode of the tube, a glass seal for the envelope and a coated high emission low temperature cathode, which consists in assembling the tube with a coated cathode therein, exhausting the tube, and, during the process of exhaustion, baking the entire tube and subjecting the envelope by an external heating means to a temperature considerably above that to which the glass is subjected and ranging in proximity to 1000 degress C. while preventing injury to the glass seal, the cathode also being heated at this time by radiation from the envelope, then connecting current to the cathode and gradually increasing the same to normal current flow, then oscillating the tube while connected to said pump, and subsequently sealing off the tube.

7. The method of manufacturing electron tubes having a metal envelope sealed to a glass member forming the envelope and a low

temperature high emission cathode which consists in coating a metal base with thorium nitrate, drying such coating on the base, mounting the coated base in a tube to provide a cathode therefor, exhausting the tube, and, when the tube is extemely well evacuated but while the process of exhaustion is continued, heating the tube and the cathode from an external heating means, raising the temperature of the cathode by such means to about 800 degrees C. and raising the temperature of the anode above the melting point of glass and at the same time maintaining the temperature of the seal between the glass and the anode below the melting point of glass, then bombarding the tube by applying current to the metal envelope, subsequently connecting sparking current to the tube and again bombarding the tube, and sealing the tube off the pump for operation.

In testimony whereof I hereunto affix my signature.

FREDERICK S. McCULLOUGH.