Aug. 29, 1933. F. S. McCULLOUGH 1,924,368

VACUUM TUBE

Filed March 13, 1924

Fig. 1

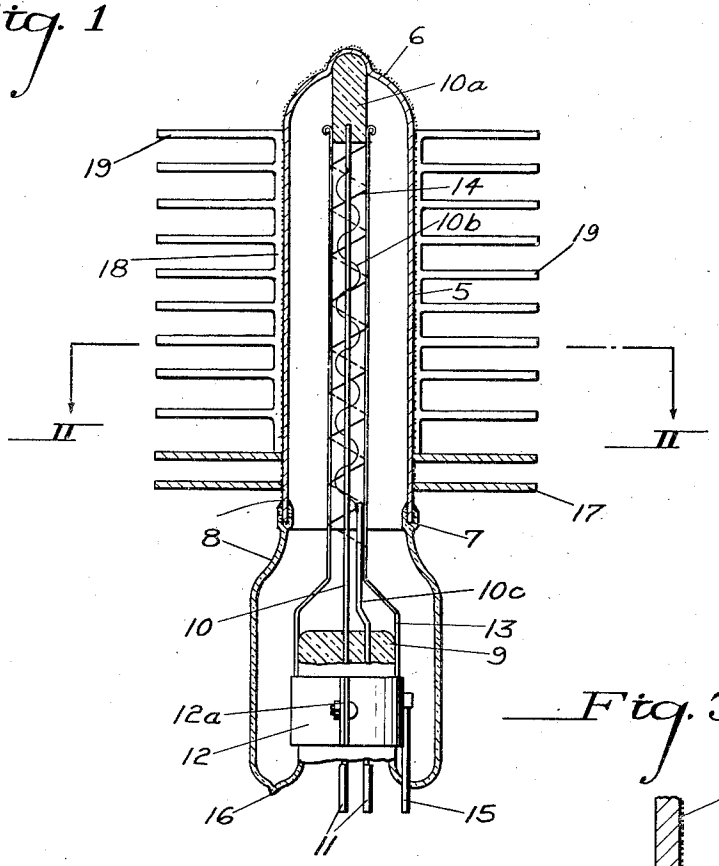


Fig. 3

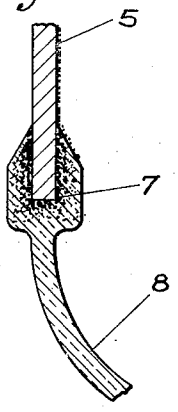
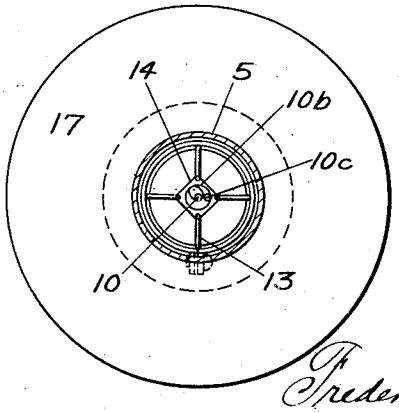


Fig. 2



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VACUUM TUBE

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11 Claims. (Cl. 250—27.5)

This invention is for an evacuated vessel, and relates particularly to an evacuated vessel comprising a part of a thermionic or electron tube structure.

In electron tubes of the larger sizes—what are generally termed "power tubes"—the dissipation of the heat from the anode has become a serious problem. Efforts have been made to overcome this by the construction of a tube in which the major portion of the envelope is a cylindrical metal tube which is also the anode of the tube. The other electrodes, as the grid and cathode, extend along the inside of this metal tube. The grid and the cathode must be insulated from each other and from the anode or metal shell, necessitating a glass base which also provides a readily fusible seal for the vessel. The advantage of such a tube resides in the fact that water or other cooling liquid may be circulated around the anode in direct contact therewith.

Such a structure as heretofore made, has had disadvantages of a serious nature. In the first place, difficulty is encountered in the formation of a seal between the glass base and the metal envelope which will not be ruptured when the tube is heated to extremely high temperatures to be evacuated, and which would not be ruptured under the varying thermal conditions resulting from the operation of the tube and the water cooling thereof.

A second objection resides in the fact that copper was the only commercially available metal which could be used for the anode and yet have the glass sealed thereto so as not to rupture under varying thermal conditions. Due to the fact that copper oxidizes readily at a glowing temperature, it is extremely liable to develop microscopic faults when the tube is heated on the pump for a long period of time at a de-gasifying temperature, making it difficult to develop and maintain a high degree of vacuum in the tube. Due, also, to this property of copper to oxidize and the oxide "cake-off" and thus waste away, liquid cooling is essential in the operation of the tube.

According to the present invention, I provide a seal which may be made between glass and any desired metal which is remarkably free from any liability of rupturing under varying thermal conditions. I further provide an anode having a coating thereon rendering the under surfaces of the metal passive to oxidation, even at high degrees of heat, whereby the tube may be heated extremely hot in the de-gasifying process without injury, and which may be operated at elevated temperatures in the open air without necessitating the circulation of a cooling liquid thereabout.

My invention may be readily understood by reference to the accompanying drawing, illustrative of a vessel involving my invention, and in which

Fig. 1 is a longitudinal section through the tube;

Fig. 2 is a transverse section in the plane of line II—II of Fig. 1; and

Fig. 3 is a detail section of the seal.

In the drawing, 5 designates a metal tube having a closed end 6. This tube is preferably some other metal than copper. I prefer to use nickel, or some metal having properties similar, for my purposes, as hereinafter described, to nickel.

Sealed to the open end of the tube at 7 is a glass base or seal 8. This seal, between the glass and the nickel, is so developed that the seal is not ruptured upon the parts being subjected to varying and differing thermal conditions. The seal is formed by the incorporation with the glass, at the point of contact with the metal, of a suitable oxide, such as copper oxide, and decreasing the amount of incorporated oxide from the metal out, so that the glass close to the metal has a large proportion of oxide therein, while the percentage of oxide gradually reduces from the metal outwardly.

Inside the seal or glass base is a cylindrical mounting or stem 9 which supports a filament supporting rod 10 that extends longitudinally of the tube, its upper end being received in a quartz block 10*a* centered in the tube. Having its upper end attached to this post 10 near the top thereof, is a filament 10*b* that spirals around the post 10. The lower end of filament 10*b* connects to the top of a short post or connector 10*c*. 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 clamped together at 12*a* to frictionally retain the band on the stem. This band carries four heavy wire supports 13, suitably bent to shape, which extend longitudinally of the tube and which have their upper ends tied together about the quartz block 10*a*. A continuous wire 14 coiled around posts 13 outside the coiled 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 point where the tube is tipped off the pump.

Initially secured on 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 drawing. More could be initially provided, but as they might interfere with the heating of the shell 5 to a proper de-gasifying temperature, as hereinafter described, I preferably do not initially provide more than the two fins 17. Should it be desired, after the tube is evacuated, to have additional heat radiating surface, a sleeve 18, having radiating fins 19, may be slipped over the shell.

I prefer to form the metal tube from a metal such as nickel for the reason that this metal, when heated to a glowing temperature, has formed thereon a surface film of oxide which protects the body of the metal from further oxidation. Instead of using nickel alone, a coating of chromium oxide, or other protecting coating, may be formed on the outside of the metal, which will render the shell even more passive to oxidation, and will entirely enclose the shell in a heat-resistant non-corroding envelope. This coating of chromium oxide may be produced, for instance, by applying to the metal tube chromium nitrate and reducing the nitrate to the oxide during the initial heating of the tube to evacuate it.

After the tube has been assembled, it is placed on the vacuum pump for evacuation After a prolonged period of time, the furnace or oven—that is, the electrically heated casing generally provided on tube evacuating equipment is lowered around the tube, and the tube is baked or heated at a moderate temperature for a sustained period of time, perhaps a half hour. The gas driven out of the metal by the heat is carried away by the pump. Then a current, perhaps one-quarter of the normal operating filament voltage, is applied to the filament to further heat the tube. After being heated at this temperature for a while, the filament voltage is increased again. This operation of increasing the filament voltage and baking is carried on until finally full normal operating voltage is applied to the tube. By normal operating voltage, I mean that voltage which is applied to the tube in later actual operation to heat the filament.

When the normal operating voltage is applied to the tube, as above described, the tube still being on the pump and in the oven becomes intensely hot. By reason of the surrounding oven, it becomes hotter than it ever becomes at its normal operating temperature. It is maintained in this state for perhaps a half hour. During this time, the seal is protected from melting or collapsing by reason of the presence of the heat radiating fins 17.

When this process is effected with a copper tube, the copper oxidizes and the oxide cakes-off, so that the metal rapidly wastes away. By using a metal, therefore, having an oxide film coating that renders the body of the metal passive to further oxidation, this difficulty is avoided.

Before the tube is taken off the pump, it is oscillated for a while, that is, it is connected up to function as an oscillator, which further degasifies the tube. After that, high frequency alternating currents may be applied to the plate to further drive out the gas, after which the tube may be again baked for a time, and then tipped off.

The process of de-gasifying is that more or less generally followed in the manufacture of power tubes, and is described to show the conditions to which the metal envelope is subject in the manufacture of the tube.

In operation, the tube functions the same as any power tube. The metal envelope, in operation, is heated to a glowing temperature by the heat of the cathode. Being exposed to the free circulation of air thereabout, and being rendered passive to oxidation by its surface film of oxide, the shell dissipates the heat into the air and is not, therefore, heated to such an extent that the metal is injured, and the metal does not waste away due to oxidation, as would the usual pure copper envelope. The heat radiating fins 17 protect the seal in operation, also, and, as above noted, the sleeve 18 with the fins 19 may be used in the operation of the tube.

If desired, the tube can be water cooled or liquid cooled, although, being capable of dissipating the energy without liquid cooling, no advantages is gained by the liquid cooling of the tube.

Other oxides than chromium could be used where a surface coating is applied, such for example, as uranium oxide.

The important features of my invention reside, therefore, in the method of effecting the seal between the glass and the metal; the provision of a surface film on the metal of an exposed anode, which renders it passive to oxidation; and the provision of a tube having an anode which is exposed to air during the operation of the tube, and which may be cooled entirely by air.

I claim as my invention:

1. A vacuum tube comprising an envelope having a plurality of electrodes including a metal anode having a depression and forming a part of the envelope of the tube and exposed to atmospheric pressures, an applied envelope of chromium oxide over the anode and in immediate contact therewith to prevent oxidation of the anode, a tube element within the tube, and a support for said tube element held in position by engaging the depression in said metal anode.

2. A vacuum tube comprising an envelope a metal anode provided with a depression and forming a part of the envelope of the tube, an electrode within the anode, a member fitting into said depression for positioning the said electrode relative to said metal anode, and a heat-resistant, air-excluding chromium oxide-coating enveloping the anode.

3. An electron tube comprising an envelope, an anode which forms part of the envelope of the tube, a glass member also forming part of the envelope of the tube and fused to said anode, a grid and a cathode supported by said glass member for cooperation with said anode, ring-shaped heat radiating fins on the anode exposed to the atmosphere for conducting heat therefrom, and a chromium oxide coating for said anode for preventing continued oxidation thereof.

4. An electron tube comprising an envelope having a metal portion which comprises an electrode for the tube, a coating of uranium oxide for said metal portion, a fused glass seal on the envelope, a ring-shaped heat radiating fin formed integrally with the metal portion of the envelope and in proximity to the seal for cool-

ing the same, other heat radiating fins for said envelope for further cooling the metal portion, an electrode for cooperation with said metal portion, and a member within said tube for supporting said electrode, said member being positioned by said envelope.

5. An electron tube comprising a metal cylinder closed at one end, and having a depression in said end, a glass base sealed to the open end of the cylinder, a stem in the base, a longitudinally extending filament support in the stem projecting up into the cylinder, a heat resistant non-conducting block centered in said depression in the closed end of the metal cylinder, said support being retained in position at its free end by said block, a filament connected to the support, and a grid surrounding the filament but spaced therefrom and having its inner end engaging the block to hold it in fixed relation to the filament.

6. An electron tube comprising a metal cylinder closed at one end, heat radiating fins attached to a sleeve adapted to be fit over said metal cylinder, a glass base sealed to the open end of the cylinder, a heat resistant non-conducting block in a depression in the closed end of the metal cylinder, a longitudinally extending filament support projecting up into the cylinder and retained in position by said block, a filament connected to the support, and a grid structure in the cylinder surrounding the filament and having a plurality of rods engaging the said block and positioned thereby.

7. An electron tube comprising an envelope, a cathode, an anode exposed to the atmosphere and forming a part of the envelope of the tube, a heat radiating projection on the anode formed integrally therewith, and other heat radiating projections formed separately from said anode adapted to cooperate therewith to cool the same, said other heat radiating projections being removably supported by said anode.

8. An electron tube having an anode exposed to atmospheric pressures and provided with integrally formed heat radiating fins, a removable sleeve on the anode, a plurality of heat radiating fins on the sleeve, and an electrode supporting member within the anode and contacting therewith and an electrode supported thereby.

9. An electron tube comprising an envelope, a plurality of electrodes including an anode exposed to atmospheric pressures and which becomes heated during the operation of the tube, a glass portion seal to the metal anode, said glass portion and metal anode constituting the envelope of the tube, ring-shaped heat radiating means formed integrally with said anode for cooling the same, and an uranium oxide coating on said anode to prevent oxidation of the metal anode at operating temperatures.

10. A vacuum tube having a plurality of electrodes including an anode of nickel exposed to the atmosphere, and a film of uranium oxide on the nickel for rendering the outer exposed surface of the metal passive to oxidation at glowing temperatures.

11. A vacuum tube comprising an envelope, a metal anode provided with a depression and forming a part of the envelope of the tube, an electrode within the anode, a member fitting into said depression for positioning the electrode relative to said metal anode, and an uranium oxide coating enveloping the anode.

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