

May 28, 1946.

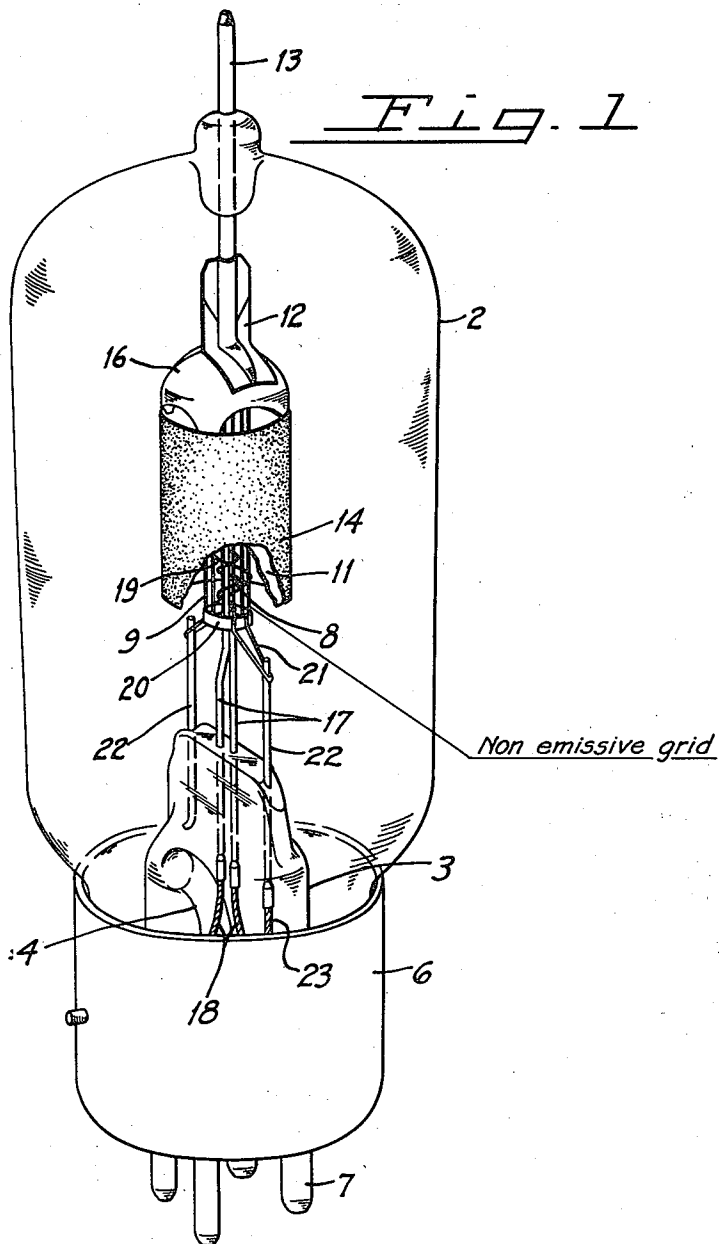
G. A. BECKER

2,401,040

METHOD OF MAKING AN ELECTRONIC TUBE

Filed Oct. 5, 1942

2 Sheets-Sheet 1



INVENTOR
GEORGE A. BECKER
BY *Harold E. Song*
HIS ATTORNEY

May 28, 1946.

G. A. BECKER

2,401,040

METHOD OF MAKING AN ELECTRONIC TUBE

Filed Oct. 5, 1942

2 Sheets-Sheet 2

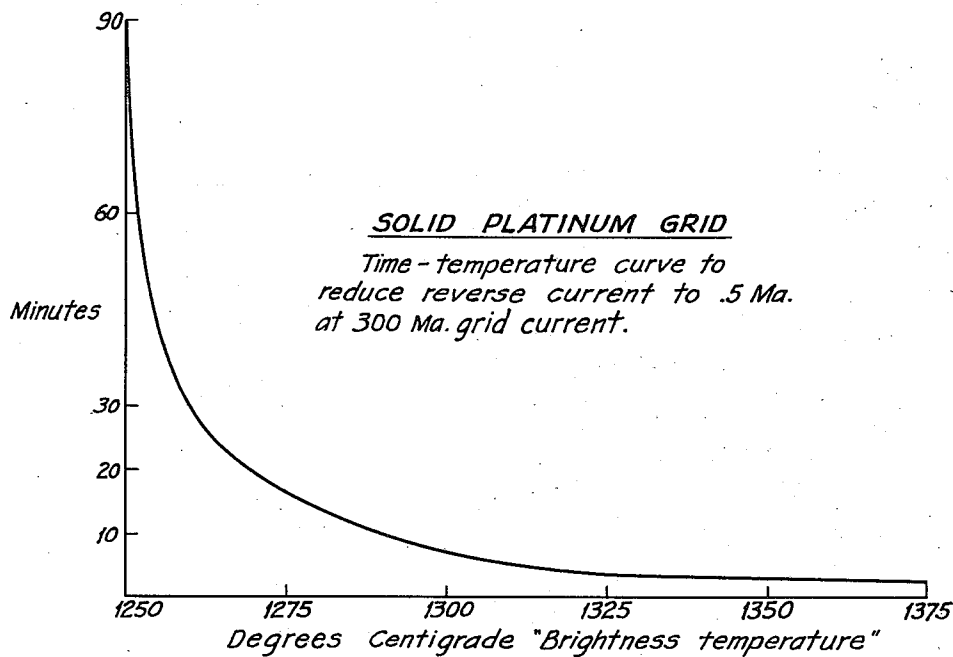


Fig. 2

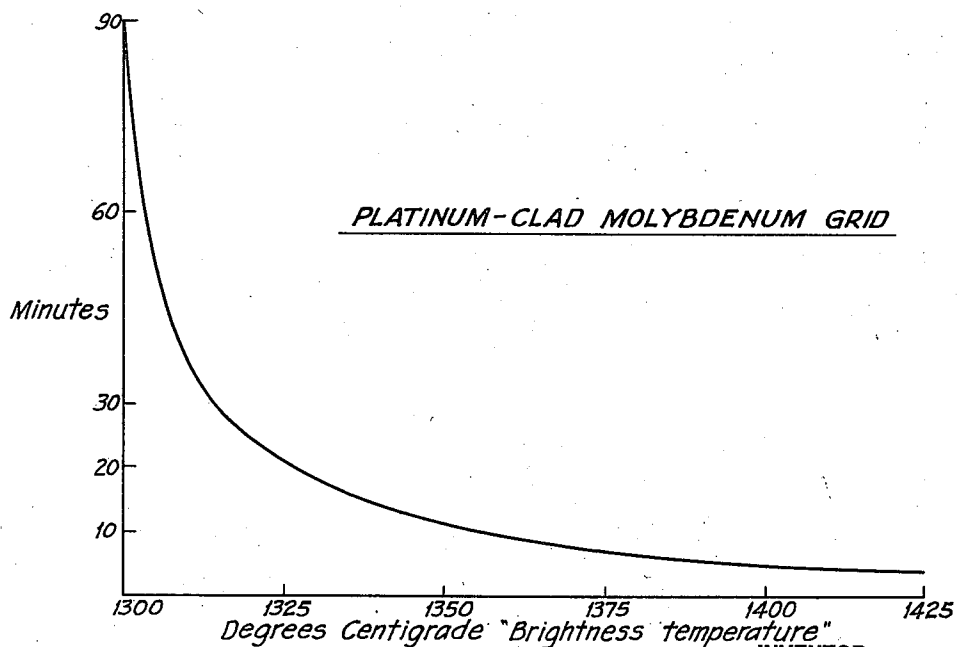


Fig. 3

INVENTOR
GEORGE A. BECKER
BY *Harold E. Sorg*
HIS ATTORNEY

UNITED STATES PATENT OFFICE

2,401,040

METHOD OF MAKING ELECTRONIC TUBES

George A. Becker, San Bruno, Calif., assignor to Eitel-McCullough, Inc., San Bruno, Calif., a corporation of California

Application October 5, 1942, Serial No. 460,911

2 Claims. (Cl. 250-177)

This is a continuation-in-part of my copending application, Serial No. 435,948, filed March 24, 1942.

My invention relates to electronic tubes, and more particularly to improvements in electrodes for such tubes.

In an electronic tube it is highly desirable to suppress emission from certain of the electrodes, particularly from the grid. Grid emission results in a reverse grid current which not only makes the tube unstable and erratic in its operation, but definitely limits the output.

The principal object of my invention is to provide a tube in which grid emission is substantially wholly and permanently eliminated.

Another object is to provide a tube in which emission from the cathode is materially increased.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of my invention. It is to be understood that I do not limit myself to this disclosure of species of my invention as I may adopt variant embodiments thereof within the scope of the claims.

Referring to the drawings:

Figure 1 is a perspective view of a tube embodying the improvements of my invention.

Figure 2 is a curve showing the variation of time with temperature required to reduce reverse current of a solid platinum grid to a negligible value; and

Figure 3 is a similar curve for a platinum-clad molybdenum grid.

In terms of broad inclusion, my tube comprises an envelope enclosing a plurality of electrodes, including cathode, grid and plate electrodes. The grid preferably comprises one of the metals, such as platinum, in group eight of the periodic table. During exhaust of the tube the grid is heated by electron bombardment above a predetermined temperature, which heating under bombardment I have found to permanently render the grid substantially non-emissive. I have also discovered that the combination of a thoriated cathode with my improved grid operates to materially increase emission from the cathode.

In greater detail, and referring to the drawings, my improved grid is shown in a tube comprising an envelope 2 of glass or the like having a re-entrant stem 3 carrying an exhaust tubulation 4. After evacuating the tube and tipping off the tubulation, a suitable base 5 having prongs 7 is cemented to the lower portions of the envelope.

The triode chosen for purposes of illustration comprises a cathode 8, grid 9 and plate or anode

11 coaxially disposed within the envelope. Plate 11 is supported by a bracket 12 on a lead 13 sealed to the top of the envelope. The plate may be of any suitable material such as tantalum. In the tube illustrated a molybdenum plate having a zirconium coating 14 is used; the zirconium functioning to improve the gettering properties of the plate. A cap 16 on the plate protects the dome of the envelope against heat and electron bombardment.

Cathode 8 is of the filamentary type, preferably thoriated tungsten, comprising a coil welded at top and bottom to a pair of leads 17 sealed to stem 3. Flexible conductors 18 connect the cathode leads with a pair of the base prongs. A thoriated filament is preferred because in combination with my improved grid the emission from such a cathode is materially increased.

From the structural standpoint, grid 9 is of the cage type comprising vertical wire bars reinforced by a spiral 19 and terminating at a base ring 20 supported by brackets 21 on a pair of rods 22 sealed to stem 3. One of these rods functions as a lead and is connected to a base prong by a conductor 23. The arrangement of the leads and mounting for the grid, as well as for the other electrodes, may be varied within wide limits; it being understood that the particular tube structure shown is merely for purposes of illustration.

The grid wire preferably comprises a metal of high melting point and low vapor pressure in group eight of the periodic table, such as platinum, iridium, rhodium, palladium or osmium. For example, I have used a grid made of solid platinum wire with good results in certain types of tubes. Platinum however is not very stiff, and for purposes of rigidity as well as economy I prefer to use a coating or plating of platinum on a core of a base metal such as molybdenum or tantalum. In any case the grid presents a surface of one or more of the metals of the character described, platinum being preferred.

Grids of platinum coated wire have been used in the past for the purpose of reducing grid emission in electronic tubes. Reduction in grid emission is usually obtained by using platinum or the like as a grid material, but harmful quantities of emission are apt to be present and there is no assurance that tubes will not fail in this respect. I have done considerable research work on this point, leading to the discovery of a method for producing a grid characterized by permanent substantial non-emission.

The method involves heating the grid above a predetermined temperature, preferably by elec-

tron bombardment, during exhaust of the tube. For a grid made of an ordinary commercial grade of solid platinum wire the treatment comprises heating the grid by bombardment to a temperature above 1000° C.; this and other temperatures referred to herein being centigrade "brightness" temperature as read on an optical pyrometer scale. From the practical standpoint, it is an easy matter to run the temperature up to a higher level, and this is preferred because higher temperatures require less time to deactivate the grid and give positive assurance of killing grid emission.

In my preferred process of making a tube the electrodes are mounted within the envelope in suitable manner, the thoriated filament being carbonized in accordance with conventional practice, and then the tube is connected with a suitable vacuum pump through tubulation 4. An oil diffusion pump is preferred, capable of reducing the pressure to a low value, say of the order of 10^{-7} mm. Hg. While pumping, the tube is heated in an oven for about 30 minutes to a temperature of about 450° C. to outgas the envelope. Next, the plate and grid are outgassed by heating under electron bombardment; such practice, in its broader aspects, being well known. For this purpose the filament is energized and a positive potential is applied to the plate alone to effect bombardment thereof by electrons from the cathode. Such bombardment results in heating the plate to a predetermined temperature, depending upon the voltage on the plate; which heating is caused by the kinetic energy dissipated at the plate when the fast moving electrons are suddenly stopped. The potential is preferably adjusted to heat the plate gradually over a period of about 30 minutes to a temperature of about 1200° C. During this heating the plate current is limited to prevent excessive ionization of gas being liberated from the plate. Next, the plate is deenergized and a positive potential is applied to the grid alone to gradually heat it over a period of about 7 minutes to a temperature of about 1300° C. Then positive potentials are simultaneously applied to the plate and grid, heating the former to about 1200° C. and the latter to about 1275° C., for a period of about 100 minutes. Finally a positive potential is applied to the grid alone to heat it to a temperature of about 1300° C. for a period of about 3 minutes.

This exhaust procedure is subject to variation, depending upon the character of tube and type of electrodes used. Thus, for a tantalum plate the plate temperature is preferably increased to about 1400° C. Much of the time required in the process is to drive out the occluded gas, particularly from the relatively massive plate.

Bombarding the platinum grid to the temperature specified is more than that merely required to drive out the gas from this electrode. My treatment of the grid is for the added purpose of eliminating grid emission.

The phenomenon of primary emission in grids is not fully understood. With materials such as platinum and the like the emissivity is apparently due to contamination in the metal. In studying this phenomenon I have directly heated a piece of ordinary solid platinum wire in a vacuum by passing current through it and observed the emission and surface characteristics of the wire with an electron microscope. As the temperature of the wire was elevated the emission appeared as bright areas on the screen image. Further increases in temperature were accompanied by in-

creased emission, the image appearing to coat or film over in patches of more pronounced activity which I believe to be contamination of higher emissivity bleeding out to the surface of the metal. When the temperature was raised sufficiently high the surface patches cleaned up, probably due to vaporization of the contaminant at the elevated temperature. The clean-up temperature for solid platinum was about 1425° C. "brightness" temperature, which is approaching the melting point of platinum.

My tests show that many metals, and particularly those of the character described, can be rendered non-emissive by heat alone, and in some cases this is feasible in a vacuum tube, the grid for example being heated to the desired temperature by the high frequency induction method. In many instances however, the temperatures required are too high for practical purposes in tube manufacture, the heat causing distortion or actual melting of the grid.

I have found that heating the grid by electron bombardment has the added advantage of causing it to clean up at a much lower temperature and a faster rate, with the positive assurance of rendering it permanently non-emissive. I believe that the improved result is due to the contamination being knocked off by impinging electrons as the contaminant bleeds out to the surface under heat, rather than depending upon heat alone to remove the foreign matter from the surface. Whatever the reasons for deactivation may be however, decontamination or otherwise, I have conclusively demonstrated that heating the electrode under electron bombardment permanently kills grid emission, which deactivation occurs within ranges of time and temperature adaptable for actual tube production.

Figure 2 is the resultant curve of time against temperature required to reduce the reverse current of a solid platinum grid to the negligible value of 5 ma. at 300 ma. grid current, which value represents substantial non-emission for all practical purposes. Actual tubes were used in securing these results, the filaments being energized and voltages applied to the grids during exhaust of the envelopes. The grids were made of an ordinary commercial grade of solid platinum wire. Temperatures were measured with an optical pyrometer, and are centigrade "brightness" temperatures as read directly on the pyrometer scale. The grids were heated by electron bombardment from the filament, and the time required to reduce the reverse grid current to 5 ma. at various temperatures was observed.

It will be noted that a temperature of more than 1000° C. is required to deactivate the solid platinum grid; the time element becoming shorter as the temperature is increased. Thus, at 1260° C. the grids cleaned up in about 30 minutes, while at 1360° C. they cleaned up in about 2½ minutes. Below 1000° C. there was no appreciable reduction in grid emission, even though the grids were held at such temperatures for protracted periods of time. It will also be observed that the clean-up under electron bombardment occurs at a much lower temperature than under heat alone, it being recalled that temperatures of the order of 1425° C. were required to deactivate a solid platinum grid by heating without bombardment. A temperature of about 1300° C. is preferred in actual practice, this temperature being harmless to the grid structure and effecting a clean-up in less than 8 minutes. In the preferred exhaust process, here-

inbefore set forth, grid deactivation occurs primarily during the 7½ minute period when the grid is heated alone, and to some extent during the period when both grid and plate are heated simultaneously, although the long simultaneous heating is mainly for outgassing purposes. The final 3 minute period of heating the grid alone is merely to give added assurance of complete deactivation and is desirable in production schedules, although not essential.

Figure 3 is a time-temperature curve similar to Figure 2, but for grids made of platinum-clad molybdenum wire; to wit, wire having a core of molybdenum with a thin coating of platinum on the surface. Such grids are stronger mechanically (stiffer) and are cheaper because less platinum is used. It will be observed that the clean-up starting temperature is higher, and that a temperature of about 1375° C. is required to deactivate the grid in 7 minutes. Because of the heat resistant core, the composit grid may be safely heated to a higher temperature, even above the melting point of platinum, and deactivation thus accomplished by heat alone. The bombardment method however still has the advantage of effecting cleanup in much shorter time.

The higher temperature (or longer time at the same temperature) required to clean up the composit wire, as compared to the solid platinum type grid, is believed due to molybdenum adhering to its contaminating constituents more tenaciously than does platinum, thus taking longer or a higher temperature to cause bleeding of the contamination out to the surface where it can be knocked off by the impinging electrons. As was the case with the solid platinum grid, once the emission has been killed off it does not reappear. The grid is rendered permanently non-emissive under all conditions of operation and for the full life of the tube.

Another unexpected result in the improved tube is that emission from the thoriated cathode is materially increased in the presence of my specially treated grid. Just what coaction there

is between the improved grid and cathode to bring this about is not understood.

While I have particularly described my invention in conjunction with a triode, it is understood that the improvements may be embodied in tubes having less or more than three electrodes; in which case one or more of the grids or other electrodes may be treated to render them non-emissive. Likewise, whereas certain kinds of metals are preferred in making my improved electrode, it is understood that other electrode materials may be advantageously treated in accordance with my process to reduce or eliminate primary emission.

It is further understood that while the invention is directed principally to the suppression of emission from an electrode, my particular process of treating the electrodes by bombardment during exhaust has advantages which make it desirable in the pumping of tubes generally where thoroughly outgassing the electrodes to produce "hard" tubes with a stable vacuum is the primary consideration.

I claim:

1. The method of treating an electronic tube having a plurality of electrodes, which comprises electronically bombarding a first electrode alone, then bombarding a second electrode alone, then simultaneously bombarding both of the electrodes together, and then rebombarding the first electrode alone.

2. The method of making an electronic tube having a cathode and a non-emissive grid in an envelope, which includes the steps of forming said grid of a metal in the class including platinum, positioning the cathode and grid in the envelope, evacuating the envelope, and, while the envelope is being evacuated, heating the grid to a temperature sufficient to drive emissive contaminant in said metal to the surface of the grid, and then bombarding said grid with electrons from the cathode to dislodge said contaminant.

GEORGE A. BECKER.