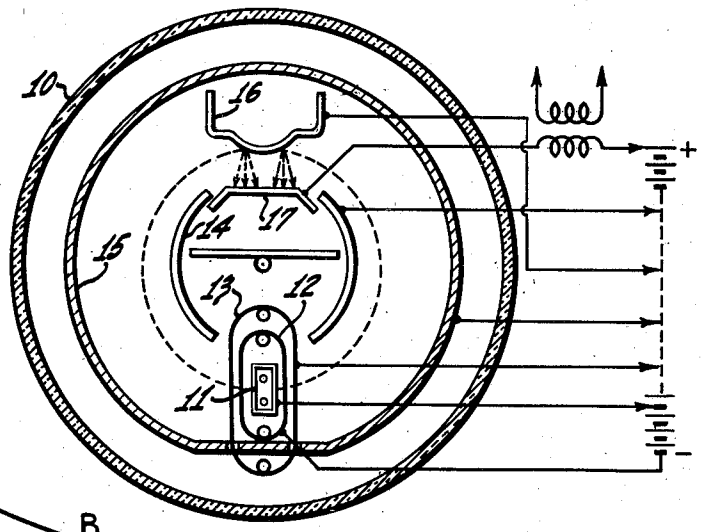
Jan. 29, 1946. H. NELSON 2,393,803

METHOD OF MAKING LONG LIFE SECONDARY ELECTRON EMITTERS

Filed Jan. 27, 1945

Fig. 1.



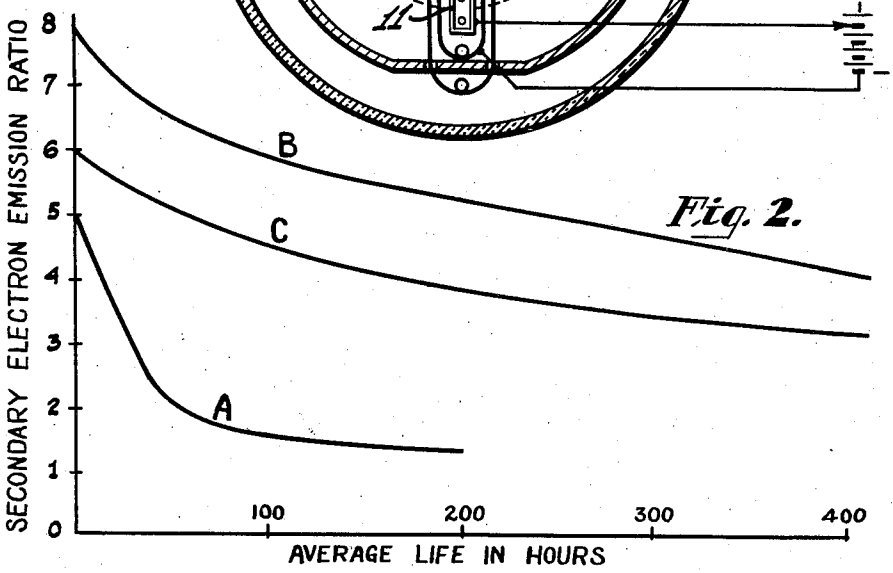


Fig. 2.

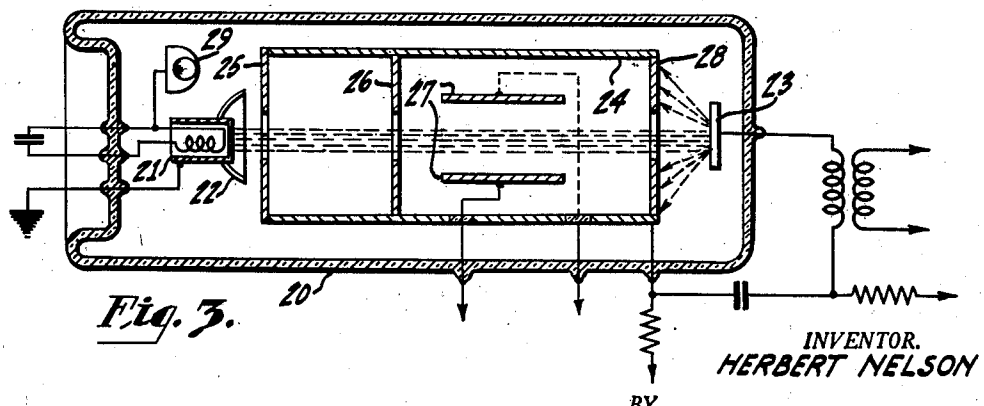


Fig. 3.

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METHOD OF MAKING LONG LIFE SECONDARY ELECTRON EMITTERS

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Application January 27, 1945, Serial No. 574,917

5 Claims. (Cl. 250—174)

My invention relates to electron discharge tubes having a thermionic cathode and a secondary electron emitter and more particularly to tubes in which the secondary electron emitter consists essentially of an alloy of magnesium, especially an alloy of magnesium and silver.

Secondary electron emitters with a thin film of magnesium oxide on a metallic support or foundation have been made by evaporating magnesium oxide from some suitable carrier such as platinum which is inert to magnesium oxide and which can be heated to a high temperature. Such films have also been formed by vaporizing magnesium in an atmosphere of carbon dioxide or other slightly oxidizing gas and thus producing magnesium oxide which deposits on the foundation to form a thin film. Emitters with such films have a comparatively high gain or ratio of secondary electrons to primary electrons when bombarded by primary electrons having the velocity of 100 or 300 volts. This gain decreases rather rapidly in use and for this and other reasons emitters with magnesium oxide films formed as above described have not been used commercially to any great extent.

An electrode made of an alloy of magnesium and silver, such as the alloy of 20% magnesium and the balance silver, disclosed in U. S. patent to Zworykin et al., 2,233,276, Feb. 25, 1941, will show considerable gain when the electrode is heated for an hour to about 400° to 500° C. in an evacuated glass envelope. Under these conditions a magnesium oxide film is formed on the surface of the electrode. Reasonably good gain can be obtained from such an emitter, but the gain decreases rather rapidly during use. I have found that better and more uniform results are obtained when oxygen to a pressure from .10 to 10 mm. of mercury is introduced into the tube during the baking period and later pumped out before final processing of the tube. Such emitters activated either in vacuum or by admitting some oxygen to the tube often show how rather low initial gain, and in most cases also show a large decrease in gain during life. I have found that the low initial gain is due to the unavoidable overheating of the emitter which occurs during sealing-in and exhaust. It is probable that this overheating also tends to accelerate the decrease in emission during life. Artificial cooling of the emitter during exhaust and coating the emitter with a fugitive protective coating which disappears during exhaust are helpful to a certain extent, but are not as practical or efficient as is to be desired.

The principal object of my invention is to provide an improved electron discharge tube having a thermionic cathode preferably of the oxide coated type and a secondary electron emitter of a magnesium alloy which will have higher gain, greater stability and longer life than the previous tubes of this type. Another object of my invention is to provide an improved method of making such a tube in which the emitter is so treated that the gain is higher and is better maintained than in tubes made by the conventional methods.

In accordance with my invention the magnesium alloy electrode, preferably a sheet of the silver magnesium alloy above referred to and containing about 20% magnesium is pre-treated under controlled conditions by heating it to about 500° C. to 700° C. in a partially evacuated chamber containing an oxidizing atmosphere having an oxygen pressure of .10 to 2 millimeters or 10 to 200 microns of mercury, until there appears on the surface of the electrode a very uniform film which shows deep golden to bluish interference color, and which may be somewhat thicker than is necessary to obtain the best gain when the electrode is used as a secondary electron emitter. This pre-treated electrode, oxidized under controlled conditions, can stand exposure to the air and can be assembled with other electrodes to form a mount to be sealed into the bulb of the tube. The pre-treatment above described prevents damage to the oxidized magnesium alloy electrode due to the overheating to which it is necessarily subjected during mounting, sealing-in, exhaust, and annealing.

The preferred procedure is to clean and wash the silver magnesium alloy electrode, place it with tweezers in a hydrogen fired metal holder which is mounted in a hard glass heating tube thoroughly cleaned with chromic acid and distilled water, and then evacuate the heating tube with liquid air on the trap to the pump from the start. A little oxygen is introduced in a known manner, the electrode heated slightly to form a thin film, the oxygen pumped out, and the electrode then baked in vacuum. Oxygen is then introduced in a known manner until the oxygen pressure is from .050 to .150 mm. or 50 to 150 microns of mercury and the electrode heated for 40 to 50 minutes by a high frequency coil from a barely visible temperature at the start, because too high a temperature of the electrode at the start may cause loss of magnesium by evaporation, to a bright red at the finish. By this procedure the electrode is heated to about 600° to

700° C. during pre-treatment. The glass heating tube is cooled to about room temperature before it is opened and the pre-treated electrode removed.

I have found that a mount of which the pre-treated magnesium alloy electrode forms a part may be sealed into the glass bulb in the usual way, the tube then baked and exhausted with sufficient heating of the metal parts inside the bulb to degas them, and that this tube so made with the pre-treated magnesium alloy electrode will show a comparatively high gain or secondary electron emission ratio which is better maintained throughout the life of the tube than is the case with similar tubes having electrodes of the same magnesium alloy which have not been pre-treated in oxygen. I have found it desirable to heat the pre-treated magnesium alloy electrode or emitter during manufacture of the tube, preferably while considerable residual gases are present in the tube, and before the getter is flashed. Whether the improved results thus obtained are due to heating the pre-treated magnesium silver alloy emitter in the presence of residual gases which may be to some extent oxidizing, or to some other action of the residual gases is not definitely known. Although heating the pre-treated magnesium silver alloy electrode to a temperature somewhat above 400° C. in an atmosphere of oxidizing residual gases or oxygen is permissible, heating it above 400° C. in a good vacuum results in a rapid decrease in emission due to diffusion of magnesium into and through the magnesium oxide film to the surface of the magnesium oxide layer on the emitter. For this reason, it is essential and is a part of my invention that the temperature of the pre-treated emitter be kept below 400° C. while the atmosphere in the tube is nonoxidizing, either as the result of good vacuum or of the presence of neutral or reducing gases, hence it is important that the emitter be heated at the proper point in the exhaust schedule and under proper conditions.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which,

Fig. 1 is a cross-section of one kind of electron discharge device in which my invention may be used to advantage;

Fig. 2 shows by curves the improvement in gain and life which may be obtained by the practice of my invention; and

Fig. 3 is a schematic longitudinal section of another type of tube in which my invention may be utilized.

The tube shown in Fig. 1 is of the type disclosed in U. S. patent to Wagner, 2,293,418, Aug. 18, 1942, in which the structural details of the tube are more fully illustrated and described. The tube comprises a glass bulb 10 enclosing a cathode 11 which is surrounded by a control grid 12 and a screen grid 13. The discharge from the cathode is in the form of arcuate electron beams indicated by dotted lines and directed by means of electrodes 14 and 15 to a secondary electron emitter 16, preferably made of the magnesium silver alloy containing about 20% magnesium. The secondary electrons flow from the emitter 16 to the anode or output electrode 17. The structure of the tube is such that this emitter 16 is unavoidably heated during the sealing of the mount into the glass bulb 10.

Fig. 2 shows by curve A about the average gain of such a tube and the decrease in gain with life if the electrode or emitter 16 is sealed into the bulb without having been pre-treated in oxygen. The gain after about 100 hours of life decreases to less than half the initial gain. I have found that if during exhaust of the tube the atmosphere in the tube is enriched with oxygen in an attempt to facilitate the formation on the electrode of a film containing magnesium oxide, the results are somewhat but no greatly better than indicated by the curve A. When this tube is made in accordance with my invention, and the electrode is pre-treated at about 700° C. in an oxidizing atmosphere, the initial gain and the gain at various periods during life is on the average, as indicated by the curve B, showing a marked increase in initial gain and a prolonged life at a gain nearly as great as the initial gain of the tube represented by the curve A. If the electrode is pre-treated at temperatures between 600° C. and 700° C., the gain during life is on the average about as shown by the curve C.

Fig. 3 shows schematically another type of tube in which my invention has been used to advantage and which comprises a glass envelope 20 enclosing an indirectly heated cathode 21 with a beam forming and focusing cathode shield 22. The discharge from the cathode is concentrated into an electron beam which is directed to a dynode 23 made of the magnesium silver alloy containing about 20% magnesium with the surface facing the cathode treated in accordance with my invention to have a high ratio of secondary electron emission and to be a good secondary electron emitter. The electron beam passes through a grid anode assembly consisting of a metal cylinder 24, which may be maintained at a positive potential with reference to the emitter 23 where the cylinder 24 is the output electrode, then through two apertured discs 25 and 26 which extend transversely of the cylinder 24 with their apertures aligned, then between a pair of deflection plates 27 inside the cylinder 24, and through a third transverse apertured disc 28. The deflection plates swing the focused electron beam back and forth across the aperture in the disc 28. The secondary electrons from the dynode or emitter surface on which the electron beam passing through the disc 28 impinges, are collected by the cylinder 24, principally on the disc 28 which is opposite the dynode or emitter 23. The details of construction of a tube of this type are more fully disclosed in U. S. patent to Herold, 2,294,659, Sept. 1, 1942.

The type of tube shown in Fig. 3 is so constructed that the dynode or emitter 23 is unavoidably subjected to considerable heat during the sealing-in operation with the result that the difficulties above mentioned are encountered. These difficulties are greatly decreased if the emitter is pre-treated under controlled conditions with oxygen and the tube is then exhausted in accordance with my invention.

I have found that the decrease in gain with life of such a tube having a pre-treated electrode of magnesium silver alloy can be somewhat lessened by maintaining in the tube a very low pressure of oxygen throughout the life of the tube. This may conveniently be done by providing in the tube a kind of reservoir which releases oxygen slowly throughout the life of the tube, for example, by slightly oxidizing some of the metal

parts of the tube or by mounting in the tube a piece of oxidized metal such as nickel which will gradually give up oxygen. The emitting surface may also be rejuvenated from time to time by developing a slight pressure of oxygen within the tube in some convenient way such as by induction heating of a capsule 29 shown in Fig. 3 and containing some material which will evolve oxygen when heated.

I claim:

1. The method of making an electron discharge device comprising a thermionic cathode and cold electrodes, one of which is a secondary electron emitter consisting of a sheet of silver-magnesium alloy in which silver is predominant, which includes heating the sheet in an atmosphere containing oxygen at a pressure of 10 to 2000 microns of mercury to produce a surface film of a golden to bluish interference color, cooling said oxidized sheet to about room temperature, mounting said oxidized sheet in normal room atmosphere in an envelope containing said cathode and said cooperating cold electrodes, baking the envelope, heating the oxidized sheet and the cold electrodes to degassing temperature, and exhausting the envelope.

2. The method of making an electron discharge device comprising a thermionic cathode and cold electrodes, one a secondary electron emitter of silver-magnesium alloy consisting predominantly of silver, which comprises oxidizing said emitter in an oxidizing atmosphere at a partial pressure of oxygen to produce a surface film showing a golden to bluish interference color, exposing said oxidized emitter to air, mounting said oxidized emitter in an envelope containing said cathode and said cooperating cold electrodes, baking and exhausting said envelope, heating said cold electrodes to degassing temperature during exhaust, maintaining said emitter during the degassing of the other electrodes and in an appreciable atmosphere of residual gases at a temperature below 400° C. and later in the exhaust heating said emitter in good vacuum to degassing temperature.

3. The method of making an electron discharge device having a thermionic cathode and cold electrodes one of which is a secondary electron emitter of a sheet of silver magnesium alloy in which silver is predominant which includes forming on the surface of the sheet in partial vacuum having a partial pressure of oxygen of from 10 to 2000 microns an oxide film thicker than the film which gives maximum secondary emission in vacuum, subjecting the oxidized sheet to the atmosphere, sealing the oxidized sheet into an envelope in room atmosphere, and exhausting said envelope.

4. The method of manufacturing an electronic device having an electrode of a sheet of silver-magnesium alloy consisting predominantly of silver which includes the steps of pre-treating the electrode at 500° to 700° C. in the presence of oxygen at a pressure of 50 to 150 microns of oxygen and thereby forming on the surface of the electrode an oxide film appreciably thicker than the film which gives maximum secondary electron emission in vacuum at 200 to 300 volts, cooling the electrode in the presence of oxygen to about room temperature, mounting the pre-treated electrode in room temperature as a part of a mount comprising a thermionic cathode and cold electrodes, sealing the mount into an envelope and baking and exhausting the envelope.

5. The method of manufacturing an electronic device comprising a secondary electron emitter of a sheet of silver-magnesium alloy consisting predominantly of silver which includes the steps of heating the sheet to from 500° to 700° C. in an oxidizing atmosphere containing oxygen at a pressure of 0.010 to 2 mm. of mercury until the surface of said sheet is oxidized to a golden to bluish color, cooling the said oxidized sheet in said oxidizing atmosphere, removing said oxidized sheet from said oxidizing atmosphere and subjecting it to normal room atmosphere, mounting said oxidized sheet as an electrode of a mount comprising a thermionic cathode and cold electrodes, and sealing the mount into an envelope.

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