

Nov. 2, 1954

H. E. SORG ET AL

2,693,546

ELECTRON EMITTER FOR ELECTRON TUBES

Filed July 10, 1948

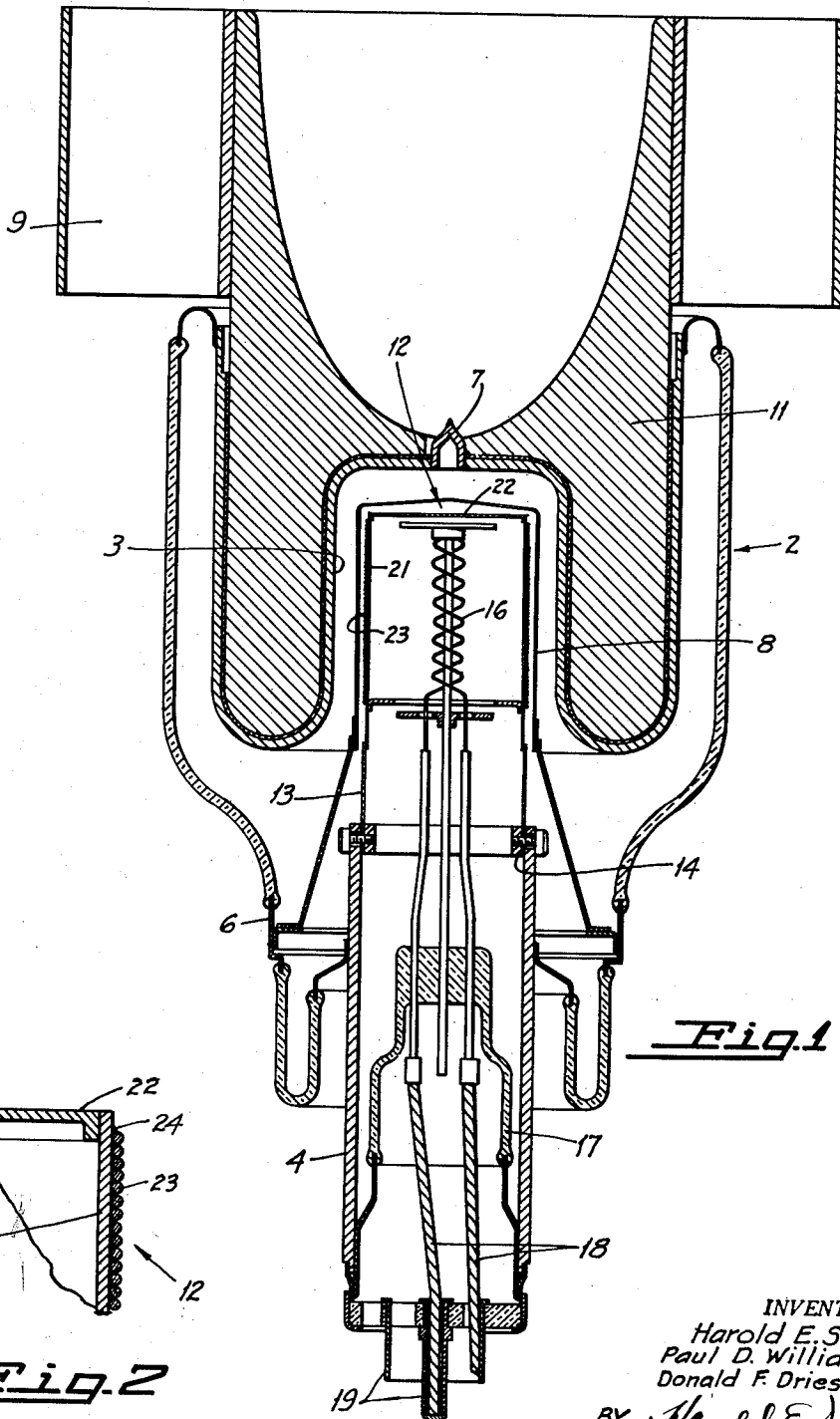


Fig. 1

Fig. 2

INVENTORS
Harold E. Sorg
Paul D. Williams
Donald F. Drieschman
BY *Harold E. Sorg*
ATTORNEY

1

2,693,546

ELECTRON EMITTER FOR ELECTRON TUBES

Harold E. Sorg, Redwood City, Paul D. Williams, Palo Alto, and Donald F. Drieschman, Los Altos, Calif., assignors to Eitel-McCullough, Inc., San Bruno, Calif., a corporation of California

Application July 10, 1948, Serial No. 38,114

4 Claims. (Cl. 313—337)

Our present invention relates to an electron emitter for electron tubes, and more particularly to an improved cathode of the thoriated tungsten type.

Thoriated tungsten wire (tungsten wire containing around 1% thorium) has long been used in the electron tube art for making filamentary type cathodes, which cathodes are heated during operation by passing current through the wire filaments. The use of thoriated tungsten as an electron emitter material has been largely limited to such filamentary type structures. The usual practice is to bend the wire into hairpins or other suitable shape, mount the filament on a stem, and then carburize the filament.

Because it is frequently desirable in some tubes to have the electrons originate from a sheet-like surface rather than from individual wires, another type of cathode widely used is the unipotential surface or indirectly heated type. The latter type cathodes have been made by coating a base metal such as nickel with electron emitter materials such as the alkaline earth metal oxides. These oxide coated type cathodes have certain limitations which make them unsuitable for high voltage operation, which limitations do not exist in a thoriated tungsten type of emitter.

The broad object of our invention is to provide an electron emitter or cathode having an emitter layer comprising thoriated tungsten wire.

Another object is to provide a unipotential surface cathode having such an emitter layer.

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

Referring to the drawing:

Figure 1 is a vertical sectional view of an electron tube embodying our improved cathode; and

Figure 2 is an enlarged detail view showing portions of the cathode.

In terms of broad inclusion our improved electron emitter or cathode comprises an emitter layer of adjacently positioned parallel strands of carburized thoriated tungsten wire. Such a layer, wherein the wire strands lie side-by-side, thus provides a sheet-like emitter body. For a cylindrical cathode the wire strands are preferably convolutions of a continuous wrapping of the thoriated tungsten wire. In our preferred construction an inner metallic support is provided, and the wire strands or convolutions overlie the support, being preferably secured thereto by a metallic bond. The method of making our preferred cathode comprises wrapping the support with convolutions of the thoriated tungsten wire to form the emitter layer, bonding the convolutions to the support, and then carburizing the emitter layer. In its operating position in the tube the cathode is preferably heated indirectly, preferably by a filament adjacent the cathode for heating it by electron bombardment.

In greater detail, and referring first to Figure 1 of the drawing, our cathode is shown in a triode type of electron tube, it being understood that this is merely for purposes of illustration and that the improved cathode may be used in many other types of electron tubes.

The tube illustrated comprises an evacuated envelope 2 having an external anode 3 at one end, a cathode stem member 4 at the opposite end, and a grid termi-

2

nal ring 6 interposed in the envelope wall between the anode and stem member. The exhaust tubulation 7 is preferably located at the end of the anode. A grid 8 projecting into the anode is connected to terminal ring 6. When air cooling is used, the heat is preferably removed from the anode by a cooler having radial fins 9 on a core 11 which projects into the reentrant portions of the anode.

Cathode 12, details of which will hereinafter be described in detail, is preferably cylindrical in shape and projects into the grid 8. The cathode is connected to the tubular stem member 4 by a sleeve 13 fastened to the upper end of the stem member by a retaining ring 14. A helical filament 16 of tungsten is located coaxially within the cathode for heating it by electron bombardment, which filament is supported by a stem 17 within member 4 and is connected by leads 18 to suitable terminals 19 for supplying heating current to the filament. By this arrangement a source of current may be connected to terminals 19 to heat filament 16 to its electron emitting temperature, and the cathode 12 may be maintained at a sufficiently positive potential with respect to the filament to effect heating of the cathode to the desired operating temperature by electron bombardment.

Our present improvements are best understood with reference to Figure 2. In its preferred form the improved cathode comprises an inner support or layer 21, preferably of a metal having a relatively high melting point and low vapor pressure such as tungsten, tantalum or molybdenum, or an alloy of such metals. In the electron tube art metals of this type are called refractory metals. A cylinder of sheet metal such as tungsten is preferred for the supporting layer 21. An ordinary commercial grade of substantially pure sheet tungsten is satisfactory for this purpose, and the inner supporting layer is preferably fabricated by rolling the tungsten sheet into a cylinder and butt welding at the seam. A tungsten cap 22 is then welded in place. The electron emitter body or layer 23 comprises adjacently positioned parallel strands or convolutions of an ordinary commercial grade of thoriated tungsten wire, preferably containing about 1% thorium, overlying the inner supporting layer 21. The strands or convolutions are preferably sintered to the supporting cylinder 21 by a metallic bonding material 24 preferably of tungsten or tungsten carbide. While the thoriated tungsten strands may be applied vertically of the cathode, we prefer to apply them as convolutions because of the ease of wrapping with a continuous piece of the wire. Wire of circular cross-section is preferred, but flattened wire or strip may be used. The thickness of the layers 21 and 23 may be varied within wide limits depending largely upon the size of cathode being fabricated. For a cathode having a diameter of about 1 3/4 inches we have used with good results an inner cylinder 21 made of 20 mil tungsten sheet wrapped with 8 mil thoriated tungsten wire.

The preferred procedure is to first coat the outer surface of the cylinder 21 with a coating composition containing finely divided particles of the metallic bonding material. A coating composition made up of tungsten or tungsten carbide powder in a lacquer vehicle is satisfactory. An ordinary commercial grade of substantially pure tungsten powder or tungsten carbide powder may be used, the pure tungsten powder being preferred. It is desirable to secure uniform coverage of the cylinder 21 with the metallic powder. A satisfactory way to do this is to apply the coating composition with a spray gun. The coated cylinder is then wrapped with the thoriated tungsten wire, the convolutions being preferably close together although some spacing may be allowed if desired. An ordinary machine lathe is a convenient tool for use in applying the convolutions. Small holes provided at the ends of cylinder 21 permit fixing the ends of the wrapping. The wrapped cylinder is then fired in an oxygen free atmosphere, preferably in vacuum, to a temperature sufficient to fuse the tungsten particles and form the sintered bond 24 between the wire layer 23 and the underlying layer 21. Since the metallic particles in the coating composition are finely divided, the particles will fuse to produce the sintered bond at a temperature below that which would melt the parts

3

being united. Heating the wrapped cylinder in a vacuum furnace to a brightness temperature of about 2200° C. for about 4 minutes is adequate.

The next step is to carburize the wire in the outer layer 23. Such carburization is for the purpose of improving the electron emission properties of the thoriated tungsten wire, as is well known in the art of making ordinary thoriated tungsten filaments. In the case of our cathode, this carburization is preferably accomplished by coating layer 23 of the cathode with powdered carbon and heating all in vacuum to a temperature sufficient to carburize the outer portions of the exposed wire. A satisfactory procedure is to coat the wire layer 23 with finely divided carbon in a lacquer vehicle, and then heat the same in a vacuum furnace to a brightness temperature of about 2100° C. for about 3 minutes.

The cathode is now ready for mounting in the tube, and from this point on the tube is handled and evacuated by known procedures used in making tubes with thoriated tungsten type electron emitters. Electron emission tests of the preferred cathode show that the cathode fabricating procedure involved, wherein the thoriated tungsten wire is united to a tungsten supporting sheet by a sintered tungsten bond, does not impair the electron emission properties of the thoriated tungsten wire. In other words, we have achieved the desired unipotential type of cathode structure and, at the same time, have incorporated in the emitter layer a material of well established electron emission properties.

In the operation of the final tube the filament 16 is brought up to its electron emitting temperature and the cathode is maintained positive with respect to the filament so that the cathode is heated to its operating temperature by electron bombardment. With the preferred cathode structure shown in Figure 2 this bombardment takes place on the inner supporting layer 21 which in turn distributes the heat to the outer layer, which has the advantage of maintaining a more uniform temperature along the emitter layer 23.

Another advantage of the preferred cathode structure shown in Figure 2 is that the inner supporting layer 21 may itself be carburized and utilized as a reservoir for continuously supplying carbon to the thoriated tungsten layer 23 during the life of the cathode. To achieve this result the inner tungsten layer 21 is carburized, at least in part, to provide a mass of tungsten carbide underlying the emitter layer 23. The preferred procedure in this case is to carburize the outer surface of the tungsten cylinder before the wire wrapping is applied, as by coating the cylinder with powdered carbon and firing it in

4

a vacuum furnace. The outer wire layer is then applied and bonded as hereinbefore described. The tungsten carbide region underlying the thoriated tungsten layer 23 thus provides a source of carbon which is available for replenishing the carbon in the adjacent thoriated tungsten layer 23 in event the thoriated tungsten tends to lose its carbon too rapidly during operation of the cathode. A longer life cathode is thus insured.

While we have illustrated a cylindrical cathode it is understood that our improvements may be used in the making of cathodes with flat surfaces as well as those having arcuate surfaces.

We claim:

1. An electron emitter for an electron tube comprising a metallic support, an emitter layer overlying the support comprising adjacently positioned parallel strands of carburized thoriated tungsten wire, and a metallic bond uniting said strands directly to the support.

2. An electron emitter for an electron tube comprising a tungsten support, an emitter layer overlying the support comprising adjacently positioned parallel strands of carburized thoriated tungsten wire, and a sintered tungsten bond uniting said strands directly to the support.

3. An electron emitter for an electron tube comprising a cylinder of sheet metal, and an emitter layer comprising convolutions of carburized thoriated tungsten wire lying side-by-side on the surface of said cylinder, and a sintered metallic bond uniting said strands directly to the cylinder surface.

4. An electron emitter for an electron tube comprising a metallic supporting layer, an emitter layer comprising adjacently positioned strands of carburized thoriated tungsten wire overlying and directly bonded to the supporting layer, and a filament facing the supporting layer for heating the emitter layer by electron bombardment of said supporting layer.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,155,426	Liebmann et al.	Oct. 5, 1915
1,529,597	Langmuir	Mar. 10, 1925
2,269,081	Felsner	Jan. 6, 1942
2,297,454	Berger	Sept. 29, 1942
2,392,397	Litton	Jan. 8, 1946
2,397,533	Chevigny	Apr. 2, 1946
2,399,005	Crawford	Apr. 23, 1946
2,450,770	Snijders	Oct. 5, 1948