

June 18, 1968

SUSUMU YOSHIDA ETAL

3,389,290

ELECTRON GUN DEVICE

Filed April 6, 1965

2 Sheets-Sheet 1

Fig - 1

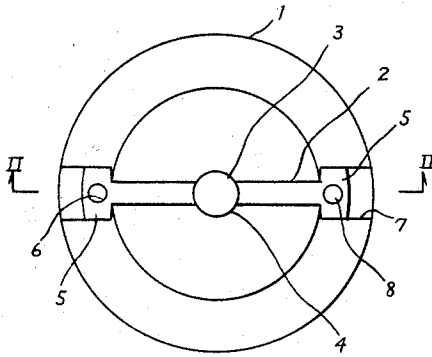


Fig - 2

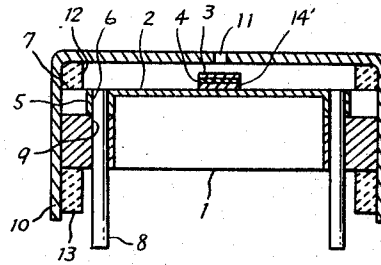


Fig - 3

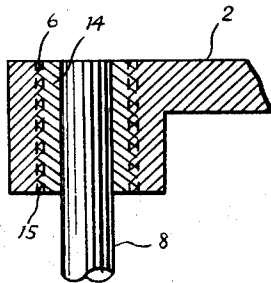
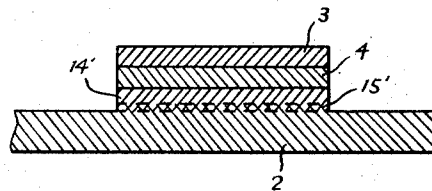


Fig - 4



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2 Sheets-Sheet 2

Fig - 5A

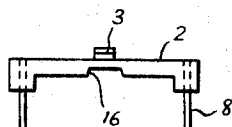


Fig - 5B

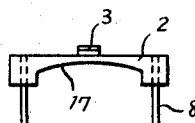


Fig - 6

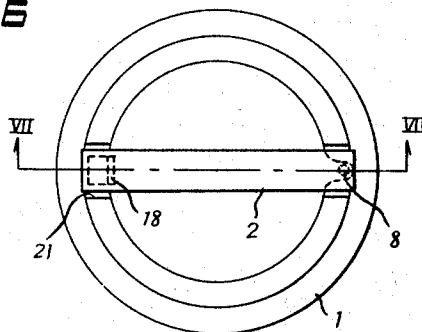
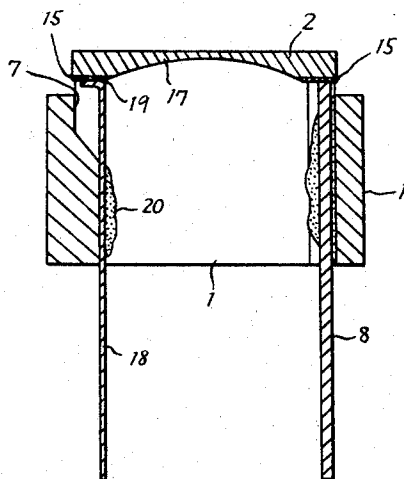


Fig - 7



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3,389,290

ELECTRON GUN DEVICE

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ABSTRACT OF THE DISCLOSURE

Electron emitter assembly wherein a graphite heating element is connected to a lead consisting predominantly of nickel by an intermediate layer including an integral carbide of a refractory metal and an alloy of nickel and the refractory metal.

The present invention relates to an electron emitter assembly of the type employed in vacuum tubes and electron guns for cathode ray tubes.

Recently, graphite heating elements have been employed in such tubes and electron guns, and high density, non-porous graphite materials have been developed for this purpose. The graphite is characterized by high density, high resistivity, high thermal stability, and great mechanical strength. The use of such graphite provides a good heating source for an electron gun device. However, since graphite itself is very stable chemically, it is almost impossible to attach lead wires of, for example, nickel or the like to the graphite heating surface for forming an ohmic contact therewith. The electrodes are sometimes mechanically contacted with the graphite heater, but such contact is unstable, and variations in the contact resistance are caused, thereby causing a non-uniform characteristic in the heater.

In view of the foregoing, one of the objects of the present invention is to provide an electron emitter assembly in which a lead is attached to a graphite type heater by means of a metallurgical bond.

Another object of the invention is to provide an electron emitter assembly in which the electron emissive material is secured to a graphite heater through an intermediate stable carbide layer.

Another object of the invention is to provide a method of attaching nickel or nickel base alloys to a graphite surface by means of an intermediate carbide zone produced in situ.

The improved electron emitter assembly of the present invention includes a graphite heating element, and a metallic lead secured to the graphite having an intermediate layer containing a stable metal carbide formed integrally with the graphite heating element, and an electron emissive material secured to the graphite heating element, the emissive material also preferably being secured to the graphite by means of the intermediate carbide layer.

A further description of the present invention will be made in conjunction with the attached sheets of drawings in which:

FIGURE 1 is an enlarged plan view illustrating somewhat schematically the principal portions of a graphite heater assembly produced according to the present invention;

FIGURE 2 is a cross-sectional view taken along the line II-II of FIGURE 1, showing the heater structure combined with a grid;

FIGURE 3 is an enlarged, partial cross-sectional view of a portion of the heater assembly of the present invention;

FIGURE 4 is a schematic, greatly enlarged cross-sectional view illustrating the manner in which cathode ma-

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terials are attached to the graphite heater in accordance with this invention;

FIGURES 5A and 5B are views in elevation of modified forms of the graphite heater structure;

FIGURE 6 is a plan view of another modified form of the invention illustrating the manner of securing the graphite heater to the support to permit thermal expansion of the heater in its lengthwise dimension; and

FIGURE 7 is a cross-sectional view taken substantially along the line VII-VII of FIGURE 6.

As shown in the drawings:

The heater structure of the present invention has been shown in the environment of an electron gun for a cathode ray tube for purposes of example. In FIGURE 1, reference numeral 1 has been applied to a ceramic header, across which there is a graphite heater strip 2. An electron emissive material 3 such as a combination of barium and strontium oxides is disposed on a nickel base plate 4 and is secured centrally of the graphite heater strip 2 in a manner which will be explained subsequently.

The graphite heater strip 2 has enlarged end portions 5 at both ends through which holes 6 extend. The upper surface of the header 1 has a pair of opposed grooves 7 formed therein in which the enlarged portions 5 of the graphite strip are received. The enlarged portions 5 may be suitably cemented to the header 1. An electrically conductive lead 8 extends through a hole 9 formed in the header 1, and its upper end extends into the hole 6 of the graphite heater 2.

Referring to FIGURE 2, reference numeral 10 refers to a grid disposed about the electron gun device, having a centrally disposed aperture 11 for the passage of electrons. A spacer 12 extends between the header 1 and the grid 10, and an annular retainer 13 composed of an insulating material spaces the grid 10 with respect to the outer periphery of the header 1.

In accordance with the present invention, the leads 8 are preferably made of nickel, or a nickel base alloy such as nickel-cobalt, or nickel-iron, the alloys containing at least 50% nickel. The leads are inserted into the aperture 6 of the graphite heater element 2. Prior to insertion, the lead 8 is coated with a material which forms a stable carbide with graphite, particularly a metal such as molybdenum, tungsten, titanium, vanadium, tantalum, niobium, zirconium or chromium, or other alloys. These metals are applied to the lead as a powder in combination with an organic binder which holds the powder onto the lead. This suspension of the metal particles in the binder can be applied in the form of a paste or can be painted or sprayed on the graphite heater to form a layer identified at reference numeral 14 in FIGURE 3 interposed between the lead 8 and the heater 2. The assembly is then heated to an elevated temperature, usually in the range from about 1100° C. to 2000° C. in a non-oxidizing atmosphere which may be vacuum, or an inert atmosphere such as hydrogen or nitrogen, argon, krypton, or the like. The metal 14 and the carbon of the graphite heater 2 thereupon form a carbide containing layer 15 which is diffused into the body of the graphite and which firmly joins the lead 8 with the heater element 2. When molybdenum is employed as the metal, the alloyed layer 15 may include a carbide such as MoC or Mo₂C, or both. The metal of the lead 8 and the carbide forming metal also form an alloy between them, firmly joining the two together, resulting in a metallurgically bonded union between the metal of the lead and the graphite of the heater element.

FIGURE 4 of the drawings illustrates a greatly enlarged view of a cathode assembly produced according to the present invention. An electron emission device 3 consisting of a mixture of barium oxide and strontium oxide or the like, is deposited on a base metal 4 composed,

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for example, of nickel, and the base metal 4 is mounted on a graphite heater 2. The nickel base 4 is attached to the graphite heater 2 through the interposition of a carbide forming metal layer 14'. Upon treatment of the assembly at the elevated temperature condition specified previously, a carbide layer 15' appears between the carbide 2 and the intermediate metal layer 14', providing a secure metallurgical bond between the two.

FIGURE 5A illustrates still another example of a graphite heater of the present invention in which the thickness of the graphite heater 2 is decreased by providing a concave portion 16 centrally of the length dimension of the heater 2, and positioning the cathode material 3 above this reduced thickness portion. This type of structure has been found to enhance the efficiency of the heater elements. In FIGURE 5B, the underside of the graphite heater has been rounded to provide a curved face 17 for the same reason.

FIGURES 6 and 7 illustrate a modified form of the invention in which the graphite heater 2 is permitted to expand upon heating in the direction of its length. For this purpose, the heater 2 is mounted in spaced relation to the header 1. One end of the graphite heater 2 is mounted securely to the header 1, while the other freely extends into a slot 21 of greater width than the width of the graphite heater 2. One of the leads 8 may be of typical circular configuration, while the lead attached to the free end of the graphite heater 2 takes the form of a nickel foil 18 joined to the graphite heater 2 at a junction identified at reference numeral 19. The other end of the foil 18 is cemented at the base of the header 1 as by means of an adhesive cement layer 20. The foil 18 is joined to the heater 2 by means of the metallurgical carbide-containing bond identified by a carbide layer 15. Typically, the diameter of the lead 8 ranges from about 0.4 to 0.6 millimeter, and the thickness of the nickel foil may be 0.05 millimeter by 1.2 millimeters in cross-section.

The type of graphite preferred for use in accordance with the present invention has the following characteristics:

Limiting temperature -----°C. >3000
Resistivity -----microhm-cm. >1000
Thermal conductivity -----Kcal./m./hr./°C. <15
Thermal expansion coefficient ---per °C. <3.0×10⁻⁶
Modulus of elasticity -----kg./mm.² >2000
Bending strength -----kg./cm.² >500

Graphite of the above characteristics is cut and processed into a desirable shape. A typical size is a length of 10 millimeters, and a rectangular cross-section measuring 1.2 millimeters by 0.2 millimeter. In preparing the bonding agent, a mixture of fine powders of tantalum and molybdenum may be combined in a ratio of 1:1 by weight, and mixed with nitrocellulose and N-butyl acetate and then applied to the metallic lead, or as a coating on the apertures 6 of the graphite heater. The resulting assembly is heated, with the temperature being raised at the rate of about 30° C. per minute, and maintained in vacuum at 1600° to 2000° C. for 20 to 30 minutes. The result is the production of an alloyed layer 15 containing stable metallic carbides. The nickel lead may be bonded to the carbide forming metal by resistance welding at the contact points. The resultant heater may be mounted on a ceramic header such as shown in FIGURE 1 by cement composed principally of aluminum phosphate. Then, the surface of the heater is subjected to lapping by means of paraffin wax. Through the lapping operation, the thickness of the heater is reduced to about 0.1 millimeter.

As another example, fine powders of nickel, molybdenum, and titanium in the ratio of 7 to 2 to 1 by weight

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were mixed with the above mentioned binder, and applied to the nickel lead which was then laid on the graphite surface. The assembly was maintained at 1300° to 1500° C. in a reducing atmosphere. Since nickel has a low melting point, the surface of the alloyed layer is covered with a nickel layer. Accordingly, the union between the nickel leads and the graphite was secured and readily achieved.

It should be evident that various modifications and variations can be effected without departing from the scope of the novel concepts of the present invention.

We claim as our invention:

1. An electron emitter assembly comprising a graphite heating element, support means carrying said graphite heating element, a metallic lead consisting principally of nickel secured to said graphite by an intermediate layer containing a stable metal carbide formed integrally with said graphite heating element, said lead and the metal of said carbide forming an alloy therebetween, and an electron emissive material secured to said graphite heating element.

2. The assembly of claim 1 in which said metal carbide is a carbide of a metal selected from the group consisting of molybdenum, tungsten, titanium, vanadium, tantalum, niobium, zirconium, and chromium.

3. The assembly of claim 1 in which said electron emissive material is bonded to said graphite through a metal carbide integrally formed in said graphite.

4. An electron emitter assembly comprising a graphite heating element, support means carrying said graphite heating element, a metallic lead consisting principally of nickel secured to said graphite and having an intermediate layer containing a stable metal carbide formed integrally with said graphite heating element, said lead and the metal of said carbide forming an alloy therebetween, and an electron emissive material secured to said graphite heating element, said graphite heating element being shaped to provide a zone of reduced thickness in the area in which said electron emissive material is secured.

5. An electron emitter assembly comprising support means, a graphite heating element secured at one end to said support and having its other end free for accommodating thermal expansion, a metallic lead consisting principally of nickel secured to said graphite by an intermediate layer containing a stable metal carbide formed integrally with said graphite heating element, said lead and the metal of said carbide forming an alloy therebetween, and an electron emissive material secured to said graphite heating element.

6. The assembly of claim 5 in which said metallic lead is in the form of a metal foil.

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