

Sept. 25, 1945.

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2,385,380

ELECTRODE SUPPORT AND CONTACTING MEANS

Filed Jan. 6, 1944

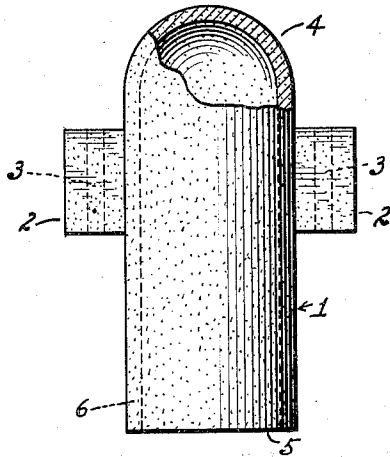


Fig. 1.

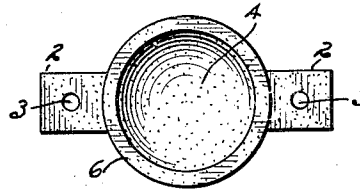


Fig. 2.

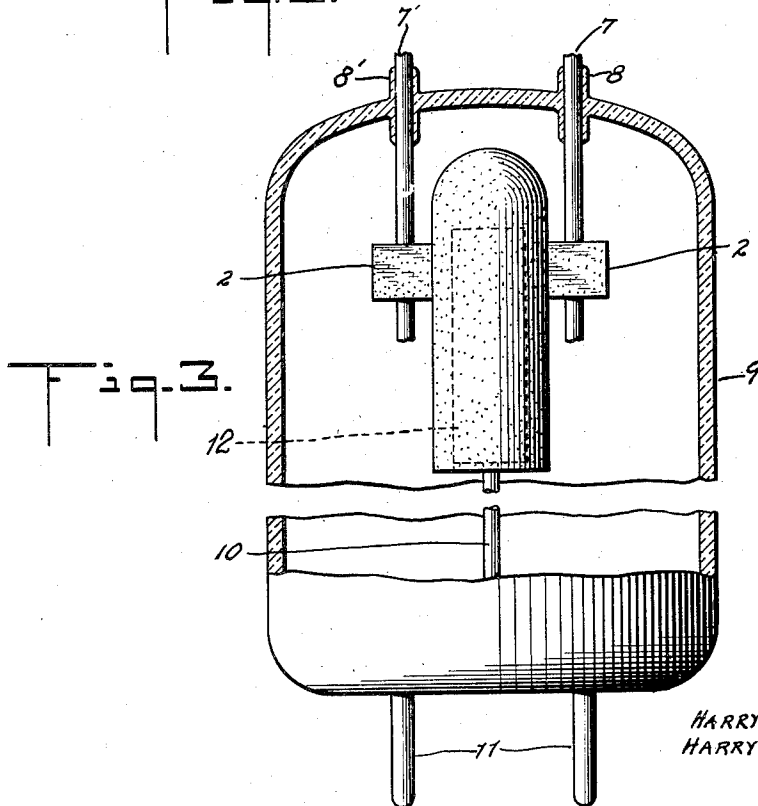


Fig. 3.

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2,385,380

ELECTRODE SUPPORT AND CONTACTING MEANS

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Application January 6, 1944, Serial No. 517,168

5 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices, and more particularly to means for establishing good electrical and mechanical connections between the electrodes of these tubes and their supporting members.

In a large class of electron tubes the electrodes are made of metal (nickel, molybdenum, tungsten, iron), and in this case, the desired mechanical and electrical connection between the electrode and a supporting lead can easily be secured by welding. When high heat dissipation is unavoidable, as in many types of power or transmitting tubes, the electrodes, in particular the anodes, are often made of carbon or graphite, because of the excellent heat radiation properties of this material, and because anodes made of graphite do not change their shape by warping or sagging as a result of the high temperatures applied to them during outgasing or in operation.

One of the major objections to the use of graphite anodes in electron discharge devices is the difficulty experienced in establishing a good mechanical joint between the anode and its support members, and particularly in obtaining a good electrical contact with supporting leads.

This difficulty is connected with the properties of the material. Compared with metal, graphite has a low electrical conductivity; it cannot be welded to a metal; and it is very brittle. Due to its low electric conductivity, a single point contact is not satisfactory for electrical connections with a current carrying lead. Special anchoring means must usually be provided to insure a number of contacting areas between a supporting lead and a graphite anode, and to establish good mechanical connections. These anchoring means must also provide a certain pressure between the surfaces of the metal lead and the graphite electrode, in order to accomplish the desired mechanical and electrical connection. The adjustment of these anchoring means is a critical operation, because of the brittleness of the material. If the anchoring is slightly too tight, the graphite may crack during the fastening of the auxiliary metal anchor, or it may crack later on during the heating of the anode, because of differences in the heat expansion coefficients of metal and graphite. The anchoring devices, such as additional metal wires or metal bonds, with associated grooves and shoulders in the graphite body of the anode, are expensive and require additional undesirable steps in mounting. In general, the contacting surfaces between metal support leads and anode remain restricted to very small, spot-like areas, in spite of the somewhat compli-

cated anchoring methods, and a high contact resistance and undesirable current distribution from these points into the anode body will prevail.

It is, therefore, a principal object of the invention to provide means for establishing a large area surface contact between a metal current-carrying support and a graphite anode.

It is another object of the invention to provide means for establishing a good electrical contact between a graphite anode and a metal support conductor which completely eliminates the need for auxiliary anchoring devices, and with the assurance that the joint between the graphite and metal wire remain rigid at all temperatures to which it may be subjected during processing or during operation.

According to another object of the invention, means are provided for insuring a rigid integral connection between a graphite anode and a cooperating metal support, which avoids the application of auxiliary welding operations during the assembly of the anode to the support.

According to a feature of the invention, means are provided which prevent the cracking of a graphite anode caused by excessive pressure applied to the anode body during the operation of joining it to a metal support.

Another feature of the invention relates to a metal support for a graphite electrode, whose heat expansion coefficient is substantially the same as that of the electrode material.

Another feature of the invention relates to a method of making a good electrical and mechanical connection between a metal support wire and graphite electrode which consists in providing a hole of considerable length in the body of the electrode, preparing a straight smooth length of metal wire of a diameter slightly larger than the diameter of the hole in the electrode, pushing the wire into the hole in coaxial relation and then heating the joint so obtained in vacuum at elevated temperature.

The invention will now be described in connection with the drawing, in which,

Fig. 1 shows a longitudinal section of a representative graphite electrode of generally cylindrical shape.

Fig. 2 is a bottom view of the graphite electrode.

Fig. 3 is a sectional view of the electrode joined to its supports which are sealed into a glass envelope.

Electrode 1 consists of cylindrical wall 6, closed at its upper end by a dome 4, and open at its lower end 5. Integral mounting blocks 2, in the form of ears or lugs, are provided at two dia-

metrically opposite sides of the cylindrical wall 6. The ears 2 may extend over the full length of the electrode, or as shown in Fig. 1, over a part of the length of the electrode only. They are preferably machined or cut out of one solid block of graphite, together with the electrode of which they form an integral part. Holes 3 are drilled into ears 2, parallel to the axis of the cylindrical wall 6. These holes must be strictly parallel, and their diameter must be held within .0001".

Support wire 7 (Fig. 3), whose diameter is slightly larger than the inner diameter of hole 3, so as to insure a push fit, is then pushed into hole 3. The support wire must be free of burrs or other surface irregularities, in order to prevent any injury to the inner surface of hole 3 during the pushing-in of member 7. Support 7 may be pushed or driven all the way into hole 3, or it may extend beyond the lower end of the hole as shown in Fig. 3. Alternatively, the support wire may only be driven part of the way of the length of the hole, about one third or one half, whatever may be convenient.

The assembly 7, 1, 7' is now sealed into glass bulb 9 (Fig. 4), by means of glass beads 8 and 8'. The other electrode (cathode) or electrodes (grid or grids) of the tube represented by block 12, are then mounted into the tube and sealed in, whereupon the tube is exhausted and processed in the usual manner. The other electrodes are not shown in the drawing, as they do not form part of the invention. Corresponding to the form of anode shown in the drawing, they are preferably arranged to be supported inside and coaxial with anode 1. One of the latter electrode supports is indicated at 10, and the corresponding lead-ins at 11.

During exhaust the anode is heated for outgasing, e. g., by a high frequency induction coil, as usual, or by electron bombardment from the cathode. This heating, which may raise the electrode to a temperature of approximately 900° C. or higher, provides a strong bond between the support 7, 7' and the anode 1 along the inner surface of holes 3 and 3'. This bond provides a good mechanical contact between support 7, 7', and the graphite body of the anode, as well as a good electrical surface contact, substantially over the full surface of the support wires embedded in the holes 3, 3'.

I have found that the best results are obtained if the diameter of the support wires is .0002" larger than the diameter of the holes, and that during heating, cracking of the graphite electrodes so supported, is substantially completely avoided if molybdenum is used as support wire. It is also possible to obtain good mechanical and electrical bonding with tungsten support wires, but in this case, additional precautions are necessary to obtain the desired bonding. If it is desired to use tungsten supports, good bonding is obtained by preoxidizing the surface of the tungsten wire before forcing it into the hole in the anode. If this step is omitted, the mechanical bond may become loose during the heating process.

The heat expansion of tungsten is considerably lower than that of graphite. Accordingly, the tightness of the cold connection between the push fit tungsten-in-graphite, will become loose during heating. Preoxidation of the tungsten surface apparently forms a sheath of greater heat expansivity compensating for the lower co-

efficient of the tungsten, thus maintaining the tight bond during heating.

It is, of course, understood, that the invention is quite independent of the general geometrical shape of the graphite electrode and the supports. The important features of the invention relate to a push fit of the metal support or metal support lead in a hole or holes provided in the graphite electrode, and to the proper correlation or matching of expansion coefficients of the metal support and the graphite material. This matching may be obtained by either choosing a metal whose expansion coefficient is nearly the same as that of graphite, or by treating the surface of the metal in such a manner that the overall expansion of the metal and its surface layer matches the graphite.

In the case of a molybdenum support in the graphite, there is the additional advantage that during the heat treatment there is provided a physico-chemical bond between the molybdenum and graphite. It has been determined by metallographic examination and X-ray diffraction patterns that this bond consists essentially of molybdenum carbide (Mo_2C).

What is claimed is:

1. In combination, a graphite electrode having at least one flange with an opening therethrough, a tungsten wire which is a tight fit in said opening when cold, said wire having a pre-oxidized tungsten-oxide surface whereby the overall cross-sectional expansion of the support is approximately the same as the expansion of the region of said flange surrounding said opening.

2. In combination, a graphite electrode having at least one elongated opening extending through a wall thereof, a molybdenum wire which is a tight fit in said opening when cold, said molybdenum wire having a surface coating of molybdenum carbide and forming a rigid bond with the graphite.

3. The method of manufacturing graphite electrodes with an integral lead-in and support wire which comprises, forming an electrode with at least one opening to receive said wire, tightly fitting the wire when cold into said opening, heating the wire and electrode to form a surface coating on said wire whereby the overall cross-sectional expansion of the wire and coating is substantially the same as the expansion of the electrode surrounding the wire.

4. The method of manufacturing a graphite electrode with an integral lead-in and support wire which comprises, forming the electrode with at least one opening to receive the wire, pre-oxidizing a tungsten wire so that the overall cross section of the wire and oxide is slightly greater than the cross section of said opening, fitting the wire into the opening, and heating the electrode and wire to a temperature of the order of 900° C.

5. The method of manufacturing a graphite electrode with an integral lead-in and support wire which comprises, forming the electrode with at least one opening to receive said wire, inserting into said opening a molybdenum wire of slightly greater cross-sectional thickness than said opening when cold, and heating the electrode and wire to a high temperature to form a molybdenum carbide bond between the wire and electrode.

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