Sept. 29, 1936. J. E. BEGGS 2,056,035

ELECTRODE STRUCTURE FOR METAL TUBES

Filed Sept. 1, 1934

Fig. 1.

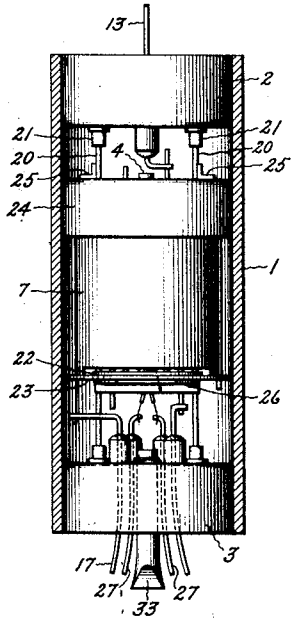


Fig. 2.

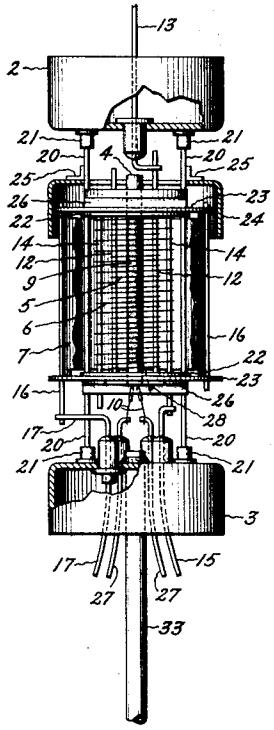


Fig. 3.

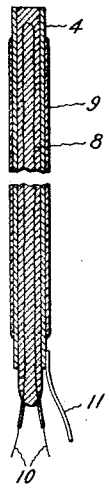
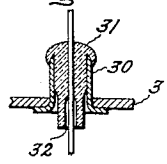


Fig. 4.



Inventor:
James E. Beggs,
by Harry E. Dunham
His Attorney.

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ELECTRODE STRUCTURE FOR METAL TUBES

James E. Beggs, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application September 1, 1934, Serial No. 742,407

6 Claims. (Cl. 250—27.5)

The present invention relates to electron discharge apparatus, and more particularly to thermionic devices employing metal envelopes.

In double-ended tubes, i. e. those having one of the electrodes sealed at one end of the envelope and another of the electrodes sealed at the opposite end, it is usual when glass is employed for the envelope material, to align the electrodes and provide the proper spacing therebetween by visual observation from the exterior of the envelope during the sealing-in process. However, when the envelopes are constituted of metal or other opaque material, this method of assembly and alignment cannot be used so that in this case, the spacing of the electrodes within the envelope has been accomplished more or less by guesswork. Such methods of assembling parts of the tubes are unsuited to quantity production to meet conditions in which accurate and reproducible operating characteristics are essential.

In accordance with the present invention, I have devised an improved tube construction, suitable for tubes of the metal envelope type in which the electrodes are secured to both ends of the tube, and which will assure positive and accurate spacing of the electrodes and other elements within the envelope notwithstanding the opacity of the envelope material.

Accordingly, the general object of the present invention is to improve the construction of "all-metal" tubes. A more specific object is to adapt the manufacture and assembly of double-ended metal tubes to quantity production methods, with particular regard to the proper spacing of the electrodes and other interior elements so that the operating characteristics of the tubes are essentially reproducible and of a predetermined character. A still further object is to provide an improved electron discharge device having a metal envelope and in which all the interior members, including the electrodes, are secured together in proper spaced relation prior to sealing of the structure in the envelope.

The invention will be better understood when reference is made to the following description and accompanying drawing in which Fig. 1 is an elevational view, partly in section, of a tube improved in accordance with the present invention; Fig. 2 shows the electrode assembly; Fig. 3 is a sectional view of a preferred form of cathode employed in the tube, while Fig. 4 is a sectional view taken through a typical leading-in conductor seal.

Referring more particularly to Fig. 1, numeral 1 designates a cylinder consisting of any readily workable, inexpensive metal, such as iron, nickel, etc., which is closed at the top (as shown) by a metal header member 2 and at the bottom by a metal header member 3. These headers conveniently take the form of a reentrant cylindrical member fitting snugly within the interior of the envelope 1 to which they are secured in any suitable and well-known manner, e. g. by welding, as will be explained hereinafter.

The interior assembly of the tube is shown more clearly in Fig. 2 and may consist of two or more electrodes together with the necessary supporting members and in which the leading-in conductor of one of the electrodes is taken out through one of the headers and the leading-in conductor for another of the electrodes is taken out through the opposite header to constitute a so-called "double-ended" tube. For purposes of illustration, the invention has been exemplified in connection with a four-electrode device having a cathode 4; an electrostatic control grid 5, a screen grid 6 and an anode 7, preferably of cylindrical configuration and surrounding the cathode. While any suitable form of cathode may be used, I prefer to employ an indirectly heated cathode of the type shown in Fig. 3. In this figure, numeral 8 designates a tungsten heater which may take the form of a "hairpin", insulatingly mounted within the cylinder 4, preferably of nickel, which constitutes the cathode proper. The cylinder 4 advantageously may be coated with electronically active material 9 such as barium and strontium oxide, obtained initially from the carbonate, as is well known in the art. Leads 10 may be taken from both ends of the heater and a lead 11 connected to the lower end (as shown) of the cathode cylinder.

The grid or electrostatic control member 5 may consist of a circular helix of wire wound on a pair of metal uprights 12, one of the uprights, the right-hand member as shown in Fig. 2, being extended and connected to a leading-in conductor 13 taken out through the upper end of the tube.

The screen grid 6 may also consist of a wire helix but of larger diameter than the control grid, and wound similarly on a pair of uprights 14. One of these uprights may be extended to connect with a leading-in conductor 15.

The anode 7 may consist of a metal cylinder, such as iron or nickel, and provided at diametral positions with a pair of rod uprights 16, one of which, the left-hand rod as shown in Fig. 2, being extended and connected to a leading-in conductor 17.

The electrode structure as a whole is mounted

on a frame constituted of a pair of metal uprights 20 which are secured by flanged metal collars 21 to the upper and lower headers 2 and 3. It is apparent that the uprights 20 serve to maintain the proper spacing between the headers 2, 3 and with the latter, constitute a rigid rectangular frame.

The control grid uprights 12 and the screen grid uprights 14 are spaced and maintained in proper position by means of a pair of disks 22, of suitable insulating material such as mica, which contain openings for snugly receiving the uprights. On the upper side of the upper disk 22 and the lower side of the lower disk 22, there is a pair of disks 23, also of mica but of larger diameter than the disks 22. The disks 23 have openings about the periphery for receiving the anode uprights 16. The upper disk 23 is of a diametral size such as to fit snugly within a metal cap member 24, the purpose of which will be explained hereinafter. The cap member is rigidly secured to the frame members 20 by angle pieces 25.

In order to maintain the mica disks 22 and 23 perfectly flat, i. e. to prevent warp, and in order to offer more rigidity to the supporting framework, I have provided at each end of the electrode structure, transverse metal bars 26 which are respectively secured to each pair of mica disks 22, 23, for example, by riveting, and also secured, as by welding, to the frame uprights 20. These bars are provided with transverse slots (not shown) which permit the upper ends of the control grid uprights 12, also the upper end of the cathode cylinder 4, and the lower ends of the screen grid uprights 14 and the lower end of the cathode 4, to pass through without contacting with the bars. The cap member 24 has a slot (not shown but indicated by the lack of cross-sectional lines along the flattened portion of the member) which corresponds to the slot in the upper bar member 26.

As shown in Fig. 2, the control grid leading-in conductor 13 is taken out through the upper header 2 by means of an improved seal which will be described presently, while leading-in conductor 17 of the anode, conductor 15 of the screen grid and conductors 27 of the heater member are taken out through the opposite header 3, also by means of improved seals. There is no leading-in conductor for the cathode 4 but there is a conductor 28 provided between the cathode and the metal bar 26 which is electrically connected to the cylinder 4 through the frame uprights 20.

For bringing out the various leading-in conductors through the metal headers 2, 3, specially designed seals are employed, an example of which is shown in Fig. 4. Each metal header is first provided with openings at the positions where it is desired to pass the leading-in conductors, and secured to each header at the respective openings, for example by welding, there is an eyelet 30 which is provided at one end (at the bottom as shown) with an outwardly extending flange which may be secured either to the under side or the upper side of the header member. There is a globule or bead 31 of glass or other vitreous material within the eyelet which may support and insulate any one of the leading-in conductors, and is provided at the position where the conductor goes through the glass, with a recess or groove 32 which serves to increase the leakage distance between the conductor and the metal eyelet. A hermetic seal is formed between the conductor, the surrounding glass bead and the eyelet by means of a gas flame which is directed at the proper position on the eyelet after the conductor and bead have been assembled within the eyelet. The seal, including the conductor, glass and eyelet members is finished as a unit before being secured to the header.

In order to insure a positive vacuum-tight seal between the glass 31 and the eyelet 30, these members preferably should have substantially the same thermal expansion characteristic at all temperatures from 0° C. up to and including the softening temperature of the glass. Thus, no stress or strain is introduced at the seal during the fabrication of the seal or during any subsequent heat treatment of the tube which contains the seal. While various metals and glasses may be employed for this purpose, the freedom from stress and strain at the seal being dependent upon the amount of the materials involved and the respective differences of thermal expansion at the various temperatures reached during the manufacture of the tube, I prefer to employ materials which have been disclosed and claimed in the Burger and Hull application, Serial No. 705,250, filed January 4, 1934 and entitled "Glass-to-metal seals", assigned to the same assignee as the present invention.

As pointed out in the Burger and Hull application, a metal which may be advantageously employed for this purpose consists of approximately 18% cobalt (Co), 28% nickel (Ni) and 54% iron (Fe), and the glass in this case may have the following approximate composition: 65% silica (SiO_2), 23% boric oxide (B_2O_3), 7% sodium oxide (Na_2O) and 5% aluminum oxide (Al_2O_3). Under certain conditions, particularly when the manufacturing temperatures are relatively low and the thickness of the metal of the eyelet relatively small, it is possible to obtain a satisfactory seal when employing for eyelet material, a metal such as molybdenum, copper or nickel in connection with any one of several well-known glasses, for example, the glass sold under the trade name of "Corning 705 AJ."

As stated hereinbefore, when the eyelet is welded to the flat portion of the header member, either on the under or upper side thereof, and further, when the glass member 31 and the metal member 30 are of the proper materials, the leading-in conductor is carried through the metal header in an insulating manner and is hermetically sealed. A sufficient number of these seals are provided to accommodate the various leading-in conductors. The seal, including the use of the metal eyelet and glass member, which provides an increased leakage distance along the glass, as explained hereinbefore, is disclosed and claimed in my patent application Serial No. 744,165, filed September 15, 1934, and entitled "Glass-to-metal seals" and is disclosed and claimed more broadly in the Elder and Gable application, Serial No. 746,808, filed October 4, 1934, and entitled "Electric discharge devices and seals therefor." These applications are assigned to the same assignee as the present invention.

In addition to these seals, the lower metal header 3 carries a metal seal-off tubulation 33 through which the interior of the envelope may be evacuated. An excess length of tubulation may be provided, as indicated in Fig. 2, the additional length being cut off during the seal-off process, as will be described presently.

When the leading-in conductor seals and the metal seal-off have been secured to the proper headers and the electrode assembly, including the frame uprights 20, assembled and secured between

the headers, connections are made between the various leading-in conductors and their respective electrodes. The metal headers and the electrode structure together with the supporting framework and elements, constitute the entire structure contained within the envelope 1. The structure as a whole is extremely rigid in view of the support offered by the header members and the frame uprights 20. It is evident that in the assembly of the structure shown in Fig. 2, careful adjustments and inspection may be made of the various electrodes and their spacings to insure proper and reproducible electrical characteristics of the tubes when permanently secured within the envelope. When the assembly has been completed, including the seals and electrical connections, there is no necessity for touching the electrodes or any other active part of the unit during subsequent manufacturing operations, because the structure may then be handled by the extended seal-off tubulation 33. Obviously, the contamination introduced at the lower end of the metal seal-off in this manner does not affect the tube since it is not only external to the tube but is later cut off after the envelope is evacuated.

The next step in the process of manufacture is to secure the header members and associated elements to the envelope. The headers 2 and 3 are of such diameter as to fit snugly within the envelope 1 and the assembly of the various elements shown in Fig. 2, is such that the outer edges of the metal headers align themselves with the edges of the cylinder 1. The entire unit may be slipped into place within the envelope 1, as indicated in Fig. 1, assuming that the electrode structure has been critically examined and proper spacings of the electrodes maintained, and then the headers 2, 3 welded or otherwise permanently and metallically secured to the envelope. For this purpose, welding electrodes, one on the inside of the flange of the header and the other on the outside of the envelope at a position opposite the inner welding electrode, are employed and these electrodes may be moved with respect to the envelope so as to provide a line or stitch weld between the headers and the envelope. Such a weld may be made hermetically tight and permanently seals the electrode structure within the rugged envelope.

After the header members have been welded to the envelope or otherwise secured thereto, the tube is placed on an exhaust system and the interior of the envelope evacuated through the metal tubulation 33. During this time, the metal envelope is heated by high frequency or by a gas or electrically operated oven to a temperature, for example, of approximately 700° C., sufficiently high to remove the occluded gases from the envelope material and yet not high enough to cause the glass members 31 to melt, or otherwise injure the non-metallic elements within the tube. The evacuation should preferably be conducted at a fast rate, something of the order of one minute, if possible, and if a high frequency coil is lowered over the envelope, it takes about ten seconds for an envelope of radio-receiving tube size to acquire the necessary temperature, and the heating process may be continued for approximately forty seconds, which then leaves about ten seconds for the envelope to cool down at the end of the exhaust. It has been found that if the heat treatment does not extend for any considerable length of time, the various insulating materials contained within the envelope are not damaged thereby and yet the deleterious gases occluded in the material of the envelope, in the electrode and insulating materials, such as water vapor, etc., are effectively removed by the pump.

When a sufficiently high degree of vacuum has been obtained, the tube is gettered in any suitable manner and sealed off the pump by closing the tubulation 33. The preferred method of doing this is by the use of a weld which is applied to the tubulation through a pair of electrodal jaws of suitable shape and connected to a source of high direct curent or alternating current voltage. A welding machine suitable for this purpose is well known in the art, as are also satisfactory energizing circuits for the welder. The jaws of a machine of this type are preferably operated by a foot pedal which causes the jaws to press together with sufficient force so that when placed on opposite sides of the tubulation 33, the latter is completely collapsed to form a flattened portion at any suitable position along the length of the tubulation. The distance between the header member and the position at which the weld is produced should be as short as possible but yet sufficiently long to permit ready access to the welding electrodes. After the weld has been made, the surplus length of tubulation may be snipped off by cutting pliers, whereupon the tube is removed from the evacuating system.

When welded in the proper manner so as completely to flatten out the tubulation 33 at the welding position, the end of the tubulation is sealed most effectively. The feature of providing a metal tubulation and the method described immediately above for effectively sealing the end of the tubulation are disclosed and claimed in an application filed in the name of Henry J. Nolte, filed September 13, 1934, Serial No. 743,832, and entitled "Metal vacuum tubes." After the tube has been sealed off, a base may be provided if desired and the various leading-in conductors connected to the usual contact pins.

In view of the foregoing, it is evident that I have provided an improved electrode structure for metal tubes, the structure being such that the electrodes are rigidly mounted and accurately spaced on a framework which includes a pair of metal headers. It is further evident that when the metal headers are being welded or otherwise secured to the cylindrical envelope, there is no opportunity for the electrodes to move out of their original position and consequently, critical interelectrode spacings are maintained, notwithstanding the opacity of the envelope. The manufacture and assembly of the interior unit as shown in Fig. 2 may be accomplished for the most part on automatic machines, on a quantity production basis so that the tube design as a whole lends itself readily to small structures, of sizes which are usually employed in connection with radio-receiving tubes. However, it will be understood that the improved structure is not limited to tubes of this size but may be advantageously employed also with larger tubes, for example, radio transmitters and the like.

Inasmuch as the envelope 1 or outer container is electrically connected to the cathode 4, hence is at the same potential, the envelope serves the additional purpose as an exterior screen electrode for intercepting electrostatic lines of force which normally pass between the control member or its leading-in conductor and the anode or its leading-in conductor. The cap member 24 serves to increase this screening effect by intercepting the electrostatic lines of force which tend to pass between the leading-in conductor 13 of the control grid and the outer surface of the anode.

The screening features shown herein have been disclosed and claimed in various scope in the Livingston application Serial No. 704,503, filed December 29, 1933, entitled "Electrostatically controlled arc discharge devices", and in my application Serial No. 742,406, filed September 1, 1934, and entitled "Screen grid metal tubes." These applications are assigned to the same assignee as the present invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electron discharge device comprising an envelope containing an electrode, said envelope including a metal cylinder closed at the ends by metal header members, a metallic structure extending between said header members and secured thereto, means for insulatingly supporting said electrode from said metallic structure whereby the electrode and header members constitute a rigid unit secured to the metal cylinder and insulated from one another.

2. An electron discharge device comprising an envelope including a metal cylinder, a combined closure and electrode unit for said cylinder, said unit comprising a pair of metal header members spaced apart by a plurality of rigid rods, an electrode structure in said envelope, means for supporting said electrode structure from said rods, said header members being secured to opposite ends of said cylinder.

3. An electron discharge device comprising an envelope containing an electrode, said envelope consisting of a metal cylinder closed at the ends by metal headers, said headers being provided with flat portions terminating in flanges which fit snugly within the cylinder as reentrant members, a rigid frame secured at each end to the flat portions of said headers, said electrode being supported on said frame and between the flat portions of said headers.

4. An electron discharge device comprising an evacuated envelope containing a plurality of electrodes, said envelope including a metal cylinder hermetically closed at each end by metal header members, said electrodes being mounted on a frame supported between said header members and secured thereto, leading-in conductors for said electrodes passing through and sealed to said header members.

5. An electron discharge device comprising an envelope containing a plurality of electrodes, said envelope including a metal cylinder hermetically closed at each end by a metal header member, a plurality of metal rods secured at their opposite ends to the header members to constitute a rigid frame, some of said electrodes being insulatingly mounted on said frame and other of said electrodes being metallically secured to said frame.

6. An electron discharge device comprising an envelope containing a plurality of electrodes including a cathode, a control grid and an anode, said envelope being constituted by a metal cylinder hermetically closed at each end by a metal header member, a plurality of metal rods secured at their opposite ends to the header members to constitute a rigid frame, said electrodes being mounted on said frame and leading-in conductors for the electrodes, the control grid and the anode conductors being insulatingly sealed in opposite header members.

JAMES E. BEGGS.