

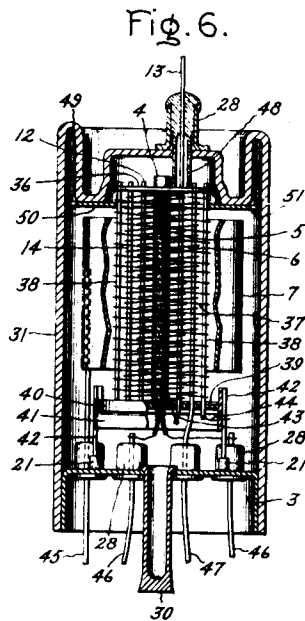
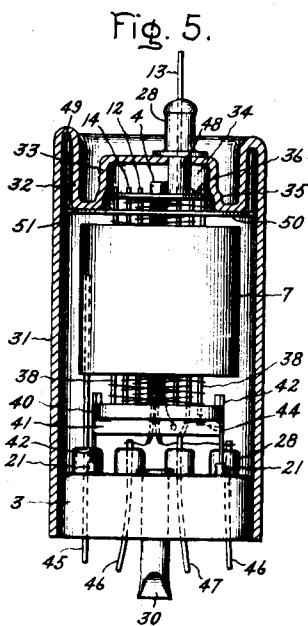
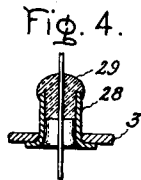
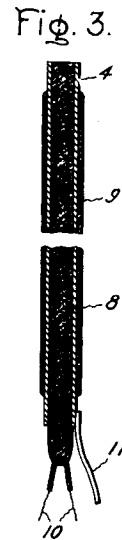
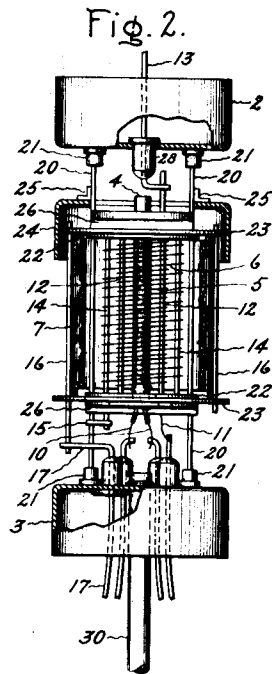
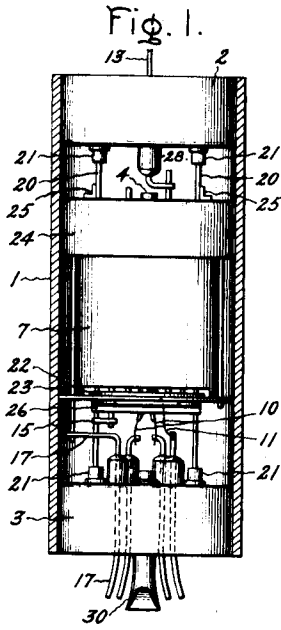
Sept. 14, 1937.

J. E. BEGGS

2,093,302

SCREEN GRID METAL TUBE

Filed Sept. 1, 1934



Inventor:
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UNITED STATES PATENT OFFICE

2,093,302

SCREEN GRID METAL TUBE

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Application September 1, 1934, Serial No. 742,406

8 Claims. (Cl. 250—27.5)

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

Objects of the present invention are to provide
5 an improved screen grid tube of the metal type; to provide a tube of this character which may be made in small receiver size, on a quantity production basis and in which the metal container serves the function of one of the screen electrodes.
10 Other objects and features will be apparent as the specification is perused in connection with the accompanying drawing in which Fig. 1 is a view, partly in section, of a thermionic device improved in accordance with the present invention and embodying the improved screen electrode; Fig. 2 is a view of the tube shown in Fig. 1 but with the envelope removed and the anode cut away to show the interior electrodes; Fig. 3
15 is an enlarged sectional view of a preferred form of cathode employed in the tube shown in Figs. 1 and 2; Fig. 4 is an enlarged fragmentary sectional view of a typical seal employed in the tube shown in Figs. 1 and 2; Fig. 5 is a modified form of metal tube employing a screen electrode, while
20 Fig. 6 is a view similar to Fig. 5 except that the upper seal and the metal seal-off are shown in section and the anode is cut away to show the interior electrode structure more clearly.

Referring more particularly to Fig. 1, numeral
30 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 may be secured in any
35 suitable and well-known manner, as by welding.

The interior assembly of the tube, as illustrated
40 more clearly in Fig. 2, takes the form of a four-electrode device having a cathode 4, an electrostatic control grid 5, a screen grid 6, all preferably of cylindrical configuration and surrounding one another. While any suitable form of cathode
45 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 which is
50 preferably of nickel and 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
55 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 wire helix, wound on a pair of metal uprights 12, one of which, the extreme
5 right-hand member as shown, is extended and joined 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
10 on a pair of metal uprights 14. One of these uprights may be extended to make suitable connection with the container by means of a transverse conductor 15 as will be explained hereinafter.

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

The electrode structure as a whole is mounted
20 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, 3. It is apparent that the uprights 20 serve to maintain the proper spacing between the headers and together with the latter constitute a rigid rectangular
25 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
30 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
35 23, also of mica but of larger diameter than the disk 22. The disks 23 have openings about the periphery to receive the anode uprights 16. The upper disk 23 is of a diametral size such as to fit snugly within the metal cap member 24, the
40 purpose of which will be explained hereinafter. The cap 24 is provided with a slot (not shown but indicated by the lack of cross-sectional lines along the flattened portion of the member), sufficiently large to permit the control grid leading-
45 in conductor and the cathode to pass through without touching. The frame members 20 also pass through the slot and are rigidly secured to the cap member 24 by angle pieces 25.

In order to maintain the mica disks 22 and 23
50 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
55

disks 22, 23, for example by riveting and also secured as by welding, to the frame uprights 20. Each of these bars is provided with a transverse slot corresponding to the slot in the cap 24 in order to 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 control grid leading-in conductor 13 is taken out through the upper header 2 by means of an improved seal shown more completely in Fig. 4 which constitutes the subject matter of my application Serial No. 744,165, filed September 15, 1934 and entitled "Glass-to-metal seals", and is disclosed and claimed in broader scope 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.

Leading-in conductor 17 of the anode, conductor 11 of the cathode, and conductors 10 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 screen grid 6 because the conductor 15 between the screen grid and frame upright 20 connects the screen grid to the headers 2, 3, and thus to the envelope 1.

The flattened portion of the heater member is provided with an opening at the position where it is desired to pass the leading-in conductor through. Secured to the header at the opening, for example, by welding, there is a metal eyelet 28 which is provided at one end (at the bottom as shown) with an outwardly extending flange in order to be secured either to the under side or the upper side of the header member. A cylinder 29 of glass or other vitreous material within the eyelet may support and insulate any one of the leading-in conductors from the eyelet and hence from the header member. A hermetic seal is formed between the conductor, the glass and the eyelet, preferably by means of a gas flame which is directed at the proper position on the eyelet after the conductor and glass have been assembled in the eyelet. The seal, including the conductor, glass and eyelet members, is completed as a unit, apart from the header member after which the eyelet is secured to the header.

In order to insure an absolutely vacuum-tight seal between the glass 29 and the eyelet 28, these members should preferably have substantially the same thermal expansion characteristic over the entire temperature range between 0° C. and the softening temperature of the glass. Thus no stress or strain is introduced at the various joints during 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 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. This application has matured into Patent No. 2,071,196. As pointed out in the Burger and Hull

Patent, a metal which may be advantageously employed for a substantially strain-free seal, regardless of the amount of metal and glass used or regardless of the temperatures reached during manufacture, consists approximately of 18% cobalt (Co), 28% nickel (Ni), 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).

As stated hereinbefore, when the eyelet is welded to the flat portion of the header member, either on the under or the upper side thereof, and when the glass member 29 and the metal member 28 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.

In addition to these seals, the lower header member 3 carries a seal-off tube 30, constituted of a readily workable metal such as steel, which is hermetically secured to the header member in any suitable and well-known manner, for example by welding or copper brazing in a hydrogen furnace. An excess of tubulation 30 is provided, 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, has been assembled and secured between the headers, connections are made between the various leading-in conductors and their respective electrodes, as has been explained hereinbefore. Thus 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. The feature of providing a pair of metal headers connected together by a rigid framework which supports the electrodes and constitutes a complete assembly unit is disclosed and claimed in my application Serial No. 742,407 filed September 1, 1934, entitled "Electrode structures for metal tubes" and assigned to the same assignee as the present invention. This application has matured into United States Letters Patent No. 2,056,035.

The next step in the process of manufacture is to secure the header members and associated elements to the envelope. The headers are of such a diameter as to fit snugly within the envelope 1, and are so spaced that their outer edges align themselves with the edges of the cylinder 1. The entire unit may be slipped into place and the headers welded or otherwise permanently and metalically secured to the envelope. The tube is then placed on an exhaust system and the interior of the envelope evacuated through the tubulation 30. 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 29 to melt or otherwise to cause damage to the non-metallic elements. The evacuation should preferably be conducted at a

fast rate after which the tube is gettered in any suitable and well known manner.

When a sufficiently high vacuum has been obtained, the tube is sealed from the pump by closing the tubulation 30 in any suitable manner, for example by simultaneously collapsing the tubulation and welding the sides thereof, as is disclosed and claimed in the Nolte application Serial No. 743,832 filed September 13, 1934, entitled "Metal vacuum tubes" and assigned to the same assignee as the present invention. 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. A base may be provided, if desired, and the various leading-in conductors connected to the usual contact pins.

As stated hereinbefore, the screen grid 6 is connected to the envelope through the short transverse conductor 15 and the frame uprights 20, consequently, the metal envelope serves not only as a rugged container for the electrodes but also as a part of the screening system for intercepting electrostatic lines of force which tend to pass between the control grid and the inner or outer surfaces of the plate. While I am aware that screen grids having a portion interposed between the control grid and the anode and another portion positioned on the opposite side of the anode have been employed heretofore in tubes, it should be noted that in the case of the prior tubes, the outer screen electrode is utilized in addition to the envelope. However, in accordance with the present invention, the screen electrode has been combined with the envelope so that one less element is necessary under these conditions. Furthermore, by connecting the inner screen electrode with the metal envelope, an external connection may be effectively made with the inner screen electrode by simply making contact with the envelope, thus eliminating the usual leading-in conductor for the inner screen electrode.

The cap 24 is provided in order more effectively to shield the anode from the control member and more particularly for the purpose of intercepting the electrostatic lines of force which pass between the leading-in conductor 13 of the control grid and the outer upper surface of the anode. It is apparent that any line drawn between the conductor 13 and the exterior surface of the anode will be intercepted either by the cap member 24 or by the envelope 1 or by both.

Figs. 5 and 6 show a modified type of screen grid tube, illustrated in the form of a pentode. The parts in these figures which correspond to the elements shown and described in connection with Figs. 1, 2, 3 and 4 have been given similar reference characters. It will be noted that the tube shown in Figs. 5 and 6 employs only one metal header, namely the element 3, because the upper end of the envelope 31 is closed by a portion integral with the envelope and produced by a deep-drawing process. The upper closure member consists of a reentrant wall portion 32 which terminates in a rectilinear wall portion 33 forming a closed compartment 34. A ledge 35 is formed within this compartment and resting against the ledge, there is a mica disk 36, the function of which is to support the upper ends of the electrodes. For this purpose, the disk 36 is provided with openings snugly to receive the various electrode uprights and the upper end of the cathode 4.

The electrode structure is shown more clearly

in Fig. 6 and comprises an indirectly heated cathode 4 which may be similar to that shown and described in connection with Fig. 3, a helical control grid 5, a helical screen grid 6, an anode 7 and in addition, a secondary emission suppression grid 37, termed a "suppressor grid", positioned between the anode and the screen grid. The various grids 5, 6 and 37 are wound around their respective uprights 12, 14 and 38, these uprights fitting snugly at the top, in openings provided in the mica disk 36 and having their lower ends supported within openings provided in a mica disk 39. The disk 39 is contained within a plate member 40 of circular configuration and provided at the upper edge with a flange in order to receive the disk 39. The plate member 40 is provided at the lower edge with a metal bar 41 which carries a longitudinal slot of sufficient size so that the various leading-in conductors for the electrodes may pass through without touching.

The plate member 40 is supported from the header member 3 by means of a pair of rigid uprights 42, at diametral positions, which are secured to the header by means of flanged metal members 21. A leading-in conductor 13 for the control member is taken out through the top of the envelope and may constitute an extension of one of the control grid uprights. The cathode 4 is connected to the longitudinal bar 42 by means of a conductor 43 and the suppressor grid is also effectively connected to the same bar by means of the conductor 44. It is apparent that the cathode and the suppressor grid are effectively connected to the envelope 31 through the uprights 42 and the header member 3.

Leading-in conductors 45, 46 and 47 are provided respectively for the anode 7, the heater 8 and the screen grid 6. These conductors are insulatingly taken through the header by means of improved seals, an example of which is shown in Fig. 4 and was described in connection with that figure. It will be understood that any other suitable form of seal may be employed for this purpose. The leading-in conductor 13 at the top of the envelope preferably employs a seal having a long extended glass portion 48 provided with a groove between the glass and the conductor, also between the glass and the eyelet 28 so as to offer increased leakage paths between the conductor and the eyelet. As in the case of the seal shown in Fig. 4, the seal shown at the upper end of Fig. 6 is also disclosed and claimed in my patent application Serial No. 744,165.

As stated in the application, Serial No. 744,165, the improved seal not only insulatingly carries the leading-in conductor 15 through the metal closure member but also serves as a support member for the mica disk 36. If desired, a seal similar to the one shown in Fig. 4 may be employed for this purpose and a spacer substituted for the portion 48 between the upper surface of the disk 36 and the lower surface of the flattened end portion of the envelope 31. It is apparent that in view of the support provided by the glass extension member 48 and the ledge 35, the mica member 36 is very rigidly held in position at the upper end of the envelope.

In addition to the seals 28 and the support members 21, the header member 3 carries a metal seal-off tube 30 which is hermetically sealed to the header as was explained in connection with Figs. 1 and 2. The end of the seal-off tube remote from the envelope is hermetically closed, preferably by welding, after the exhaust and gettering treatments have been completed. In order

to getter a tube of this type, there may be provided a gettering material indicated by reference character 49, which may consist of a piece of magnesium pressed tightly between the wall 32 and the upper end of the envelope 31, the getter being in such a position that it may be vaporized readily by torching the upper end of the metal envelope adjacent the getter. In order to prevent the getter vapor from migrating to undesired positions within the tube, it may be desirable to provide a metal baffle 50 provided with openings 51 for evacuation and gettering purposes. The baffle is of such a diameter as to fit snugly within the envelope 31 and has an opening at the center which may fit tightly about the uprights 38 of the suppressor grid.

It is apparent in Figs. 5 and 6 that the cathode and suppressor grid are connected together and are maintained at the same potential as the envelope. On the other hand, the screen grid 6 is insulated from the envelope and a leading-in conductor 47 is brought out from this grid so that various potentials may be applied thereto with respect to the cathode. It is obvious that these potentials may be predetermined in order to permit the screen grid to intercept and neutralize the effect of the electrostatic lines of force which normally pass between the control grid and the anode. Inasmuch as the envelope 31 is at the same potential as the cathode, it also will serve as a part of the screening system and will intercept the electrostatic lines of force which tend to move between the control grid and the exterior surface of the anode. The configuration of the upper end of the envelope 31 is such that the electrostatic lines of force between the grid leading-in conductor 13 and the exterior surface of the anode are effectively intercepted by the metal closure. It is apparent that this end of the envelope performs the function of not only serving as a closure for the envelope but also takes on the role of a screen member which is similar in function to the cap member 24 shown in Figs. 1 and 2. Accordingly, the improved form of envelope eliminates the necessity for the cap member and to that extent represents a more simple construction.

The tube shown in Figs. 5 and 6 offers the advantage that no leading-in conductor is necessary for the cathode or suppressor grid, since these members are maintained at the same potential as the envelope to which a connection may be readily made in order to connect with the respective elements. Inasmuch as the anode is physically independent of the remaining electrodes and is not supported by a dielectric member in common with the other electrodes, greater screening effects may be realized in a tube of the character shown in Fig. 6 than in the tube construction shown in Fig. 2. However, it will also be understood in this connection that if desired, the internal elements of the tube shown in Fig. 2 may be supported in such a manner as to employ less dielectric material than is illustrated and thus realize enhanced screening effects.

Tubes improved in accordance with my invention in which the metal container serves as part of the screening or shielding system are readily adapted to external shielding, since the container or envelope may constitute an integral part of the shielding apparatus which is provided in connection with the radio receiver set of which the improved tube may constitute one amplification or detection stage. An example of the enhanced external shielding offered by the metal container,

is when the tubes are clamped through a shield partition mounted approximately midway of the length of the envelope in such a manner that the plate lead is in one compartment provided by the partition and the grid lead is in another compartment provided by the same partition. Obviously, since the partition and the metal envelope are effectively grounded or at least connected to cathode potential, no electrostatic lines of force, regardless of their curvature or length, can possibly extend between the grid and plate leads.

In view of the foregoing, it is apparent that I have disclosed a screen grid tube which is readily adapted to be manufactured on a quantity production basis and which lends itself to any number of grid electrodes by simply changing the number of openings and distance between openings in the respective mica disks 36 and 39, with proper provision in the header member 3 for insulatingly taking out leading-in conductors from the various electrodes. The metal container 31 in connection with the upper closure member offers the most effective shielding for the contained electrodes so that in a tube of this character, there is no tendency for the production of undesired high frequency oscillations by reason of interelectrode capacity. As stated hereinbefore, considerable saving is offered by a metal tube of this type in providing enhanced screening effect without necessitating additional electrodes and leading-in conductors, since the metal container serves the dual function of an envelope as well as a screen electrode.

Some of the screening features shown herein are disclosed and broadly claimed in the Livingston application Serial No. 704,503, filed December 29, 1933, entitled "Electrostatically controlled arc discharge devices" assigned to the same assignee as the present invention. This application has matured into Patent No. 2,044,618.

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

1. An electric discharge device comprising a metal envelope provided with a metal closure, said envelope containing a cathode, an anode, a control grid, a screening electrode interposed between the anode and control grid, and a suppressor grid between the screening electrode and the anode, a metal cap member extending over one end of the anode, said envelope being connected to the suppressor grid and to the cathode, all of the electrode structure including said cap member being supported by said metal closure.

2. An electron discharge device comprising a metal envelope containing a cathode, an anode, and a control electrode, means for intercepting substantially all of the electrostatic lines of force extending between the anode and the control electrode, a portion of said intercepting means constituting said envelope, another portion constituting a screening element interposed between the anode and control grid, and a third portion surrounding one end of the anode and connected to the envelope and also connected to the screening portion which is interposed between the anode and control grid.

3. An electric discharge device comprising a metal envelope provided with a metal closure, said envelope containing a cathode, an anode, a control grid, leading-in conductors for the cathode, anode and control grid, a shielding system for intercepting all of the electrostatic lines of force extending between the anode and the control grid, said system including a screening grid interposed between the anode and control grid,

and including a metal cap surrounding the end of the electrode structure at which one of the leading-in conductors is secured to the control grid, said envelope being connected to said screening grid and cap and constituting part of the screening system, all of said elements including the electrodes being supported by said metal closure.

4. A substantially all-metal radio receiving tube of the screen grid type comprising a hollow metal cylinder closed at both ends by metal headers to form a metal envelope, a supporting framework connected between the headers, said envelope containing a cathode, an anode, a control electrode and a screening electrode, means for insulatingly supporting the cathode, control electrode and anode from said framework, said screening electrode being conductively mounted on the framework and said envelope being connected to the screening electrode.

5. An electron discharge device comprising a metal envelope provided with a metal closure and containing a cathode, an anode, and a control electrode, means for intercepting substantially all of the electrostatic lines of force extending between the anode and control electrode, a portion of said intercepting means constituting said envelope, another portion constituting a screening element interposed between the anode and control grid, and a third portion constituting a cap member which surrounds one end of the anode and extends as far as the interior surface of the metal envelope, all of said elements including the electrodes being supported by said metal closure.

6. An electron discharge device comprising a

metal envelope containing a cathode, an anode, and a control electrode, leading-in conductors for the electrodes, means for intercepting substantially all of the electrostatic lines of force extending between the anode and the leading-in conductor of the control grid, said means constituting a metal shield which consists in part of said envelope and is interposed between all parts of the anode and the said grid leading-in conductor.

7. An electron discharge device comprising a metal envelope containing a cathode, an anode, and a control electrode, leading-in conductors for the electrodes, means for intercepting substantially all of the electrostatic lines of force extending between the anode and the leading-in conductor of the control grid, said means constituting a metal shield which consists in part of said envelope and in part of a metal cap surrounding the end of the anode nearer the grid leading-in conductor, said means being interposed between all parts of the anode and the said grid leading-in conductor.

8. An electron discharge device comprising a metal envelope containing a cathode, an anode, and a control electrode, a leading-in conductor for said control electrode, and means for intercepting substantially all the electrostatic lines of force extending between said leading-in conductor and the exterior surface of said anode, said means including said envelope and including a metal cap member which extends across the end of the control electrode nearer the leading-in conductor and as far as the interior surface of the envelope.

JAMES E. BEGGS.

CERTIFICATE OF CORRECTION.

Patent No. 2,093,302.

September 14, 1937.

JAMES E. BEGGS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 32, for the word "heater" read header; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of October, A. D. 1937.

(Seal)

Henry Van Arsdale.
Acting Commissioner of Patents.