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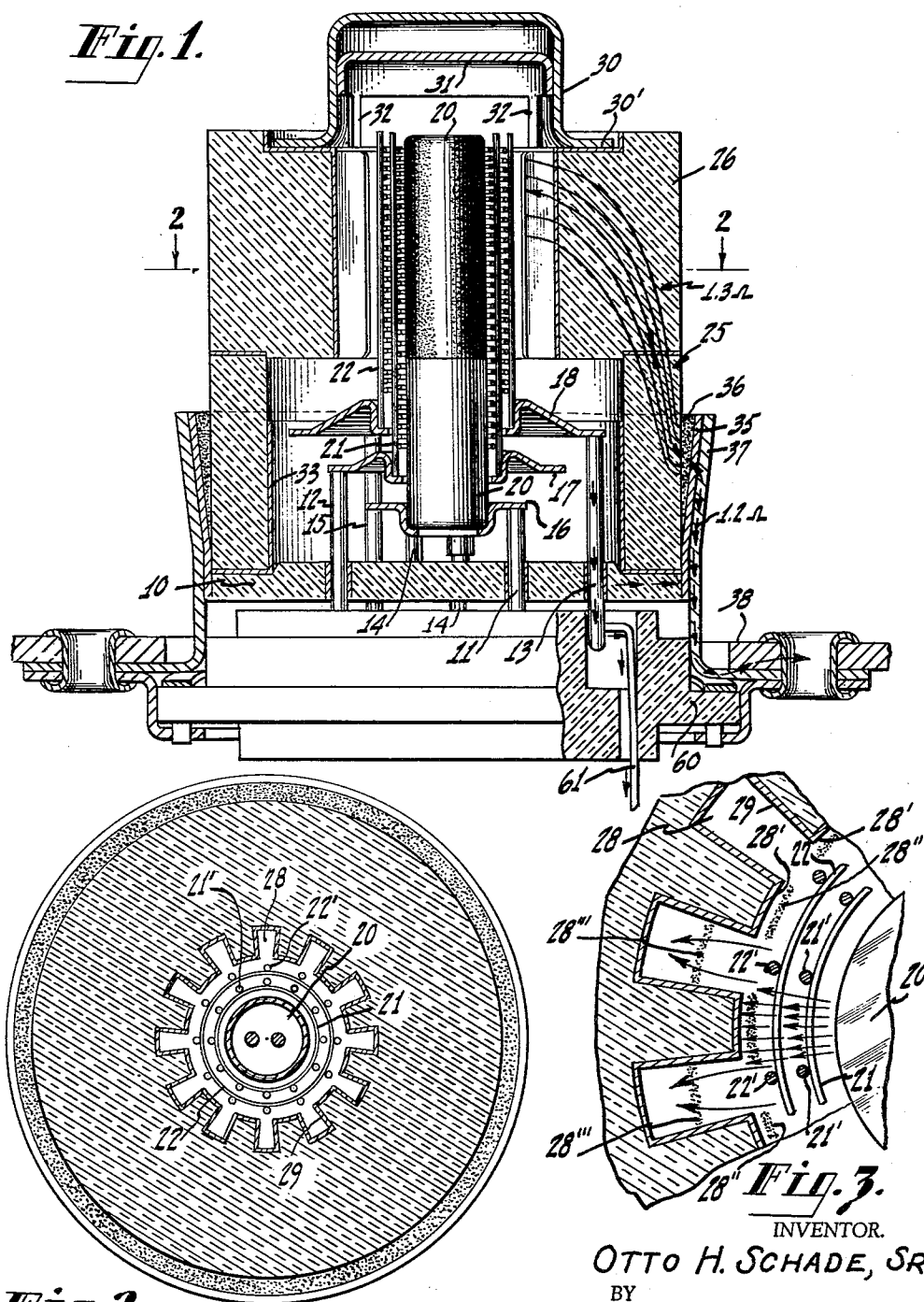
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3,054,012

HIGH POWER ELECTRON DISCHARGE DEVICE

Filed Feb. 24, 1959

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 4.

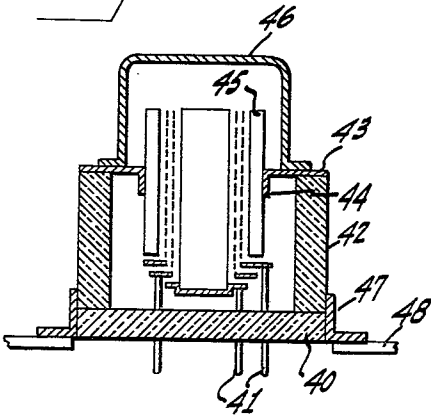


Fig. 5.

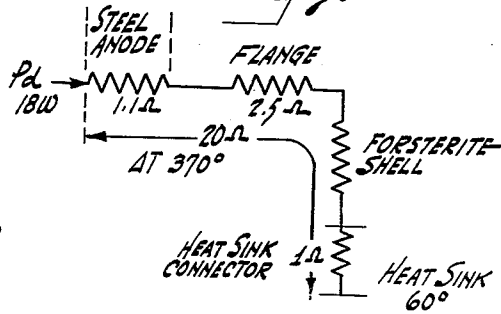


Fig. 6.

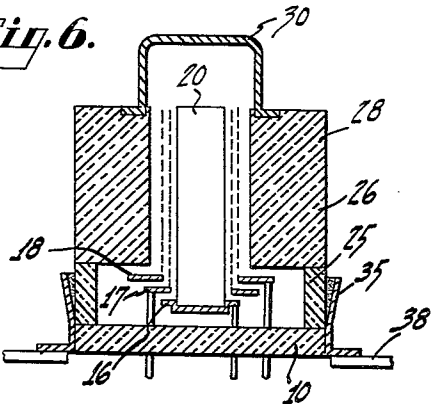


Fig. 7.

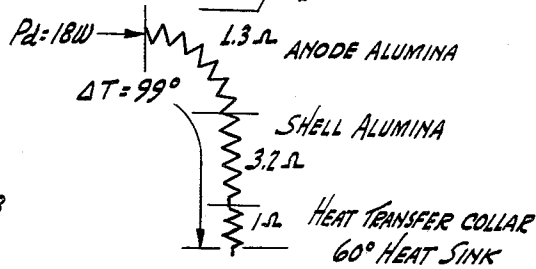
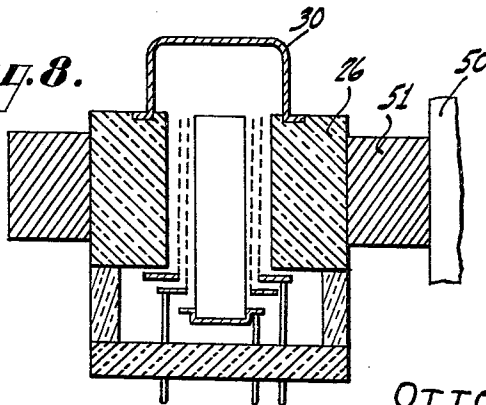


Fig. 8.



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3,054,012

HIGH POWER ELECTRON DISCHARGE DEVICE
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19 Claims. (Cl. 313-46)

My invention relates to electron discharge devices and more particularly to such devices of improved design, having increased power dissipating abilities, reduced operating temperatures, freedom from thermal stresses, useful at high frequencies and of simple and novel construction.

It is desirable to have electron tubes capable of large power outputs which, nevertheless, are small in size and which do not require space wasting, complicated heat radiating arrangements to maintain low operating temperatures needed for reliable service.

It is also desirable to have such a tube which is not subject to thermal stresses. Thermal stresses affect the vacuum tight seals in tube envelopes comprising ceramic and metal portions, and affect the relative positions of the electrodes during operation. Other desirable characteristics of such a tube are a minimum interelectrode capacity to permit operation at high frequencies and high interelectrode breakdown voltage despite small size resulting in extremely close spacing of the electrodes. Another desirable characteristic of such a tube is freedom from difficulties due to secondary emission from the anode during tube operation.

Such tubes having these advantages are not presently available.

It is therefore the principal object of my invention to provide an electron discharge device having all of the desirable characteristics described above.

I obtain these objectives by providing a heat removal circuit of low thermal resistance in the tube to an external heat sink and by utilizing novel envelope and electrode structures. I eliminate the previous difficulties due to heat by in addition making the entire heat circuit except the heat connection means, all of which will be described below in detail, out of one single material, namely ceramic.

Briefly, a tube made in accordance with my invention includes a ceramic header member in the form of a disc through which extend a plurality of terminal leads for supporting the electrodes within the envelope and to provide terminals therefor.

Mounted on the inner ends of the leads are a plurality of disc-like or flange-like supporting members supported at their peripheries by the appropriate leads and additional supporting elements. These supporting discs are provided with recessed portions and are of increasingly larger diameter moving away from the header, for supporting in concentric relationship the indirectly heated cathode, coated with electron emissive material, control grid and screen grid. This provides the mount assembly exclusive of the anode. Seated in an annular depressed portion on the periphery of the header member is an annular ceramic envelope portion or shell surrounding the flange supporting elements.

At the upper end of the envelope is mounted a massive annular anode portion which is of smaller inner diameter than the first mentioned ceramic envelope portion. The anode portion is fluted on the inside and extends coextensively with the coated portion of the cathode. The inner wall of the anode portion of the envelope is provided with a metallic coating to form the anode which thus is in direct physical and heat transfer contact with the anode portion of the envelope. The upper end of the anode portion of the envelope is closed by a cap-shaped conducting

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member electrically connected to the anode and serving as the anode terminal. The various portions of the envelope and the leads may be sealed vacuum tight by previously metallizing the ceramic portions of the envelope to be sealed to each other and to the other metallic elements of the device.

With the envelope construction as disclosed, it is possible to closely space the anode with respect to the other electrodes while at the same time providing maximum heat transfer from the anode. By making the inner diameter of the lower or shell portion of the envelope larger than the inner diameter of the anode portion, sufficient room for the novel supports for the other electrodes is provided despite the very close spacing of the smaller diameter anode electrodes in the anode portion of the envelope. In addition, a further advantage is that heat generated at the anode moves radially outward and since the annular cross section increases rapidly in moving outwardly, the result is a heat path of very low resistance. Because the shell portion has a large diameter and a thick wall, a large transverse cross section results providing a low heat resistance from the anode portion of the envelope. The arrangement described permits the minimum size of tube while providing the necessary space for enclosing the electrodes and at the same time providing the many advantages that the above-described construction has.

Because of the ceramic header and the elimination of glass as part of the envelope wall, the entire tube can be processed at very high temperatures insuring thorough degassing. Because of the relatively good heat conductivity of the ceramic, heavy parts can be used avoiding strains normally introduced by glass to metal seals. Ceramic is an excellent insulator, has good high frequency characteristics and low electrical losses. Ceramic is much stronger than glass as well as having good thermal shock resistance.

The base portion of the envelope is provided with a collar in contact with the outside wall of the envelope and the disc-header member to provide a heat transfer connection. Thus a heat circuit can be provided from the anode coating to the ceramic portions of the envelope including the header to the metallic outside collar which collar may be inserted into a heat transfer member on a supporting panel forming the heat sink which dissipates the heat generated in the anode.

The collar is placed as close to the lower portion of the anode as consistent with the required anode capacitance, which should not exceed certain values, and with insulation requirements. This is done to reduce the thermal resistance in the cylindrical part of the envelope by reducing the length of the heat path in the lower cylindrical or shell part of the envelope.

In order to reduce interelectrode capacity as well as increase voltage breakdown between electrodes, I utilize grid members having a plurality of longitudinally extending side rods of very small diameter and having their laterals preferably aligned and supported on the inside of the side rods permitting close spacing between the control grid and the cathode resulting in a high transconductance tube. The side rods, when more than one grid is used, are in alignment and register with the center of the flutes in the anode thus reducing anode-to-grid capacity and increasing the distance between the side rods of the grids and the anode to increase the voltage breakdown paths. In addition, the flutes assist in secondary emission suppression.

Referring to the drawings:

FIG. 1 is a longitudinal section of an electron discharge device made according to my invention;

FIG. 2 is a transverse section taken along the line 2—2 of FIGURE 1;

FIG. 3 is an enlarged partial view of FIG. 2 showing the electron paths;

FIG. 4 is a schematic longitudinal section of one type of tube intended for high power operation;

FIG. 5 is a schematic diagram of the heat circuit of the tube shown in FIG. 4;

FIG. 6 is a schematic longitudinal section of the tube shown in FIG. 1;

FIG. 7 is a schematic of the heat circuit of the tube shown in FIG. 6; and

FIG. 8 is a schematic longitudinal section of another form of an electron discharge device made according to my invention.

Referring to FIGS. 1 and 2, an electron discharge device made according to my invention includes the header member 10 of ceramic material preferably alumina or byrellia through which extend the various terminal lead and support members 11, 12, 13 and 14. This header member serves as a closure member for one end of the envelope. Additional supporting members such as 15 may be mounted within the envelope, preferably two supports in addition to the lead for each electrode. These leads and supports are sealed vacuum tight in the header 10. Supported at the upper and inner ends of the various leads and supports are the cup-shaped flange members 16, 17 and 18 which support in turn the cathode 20, control grid 21, and screen grid 22, these grids being wound with laterals on the inside as shown in FIG. 2. The side rods 21' and 22' of the grids are in alignment. (See FIGS. 2 and 3.)

Extending upwardly and sealed to the header member 10 is the annular supporting wall or shell member 25, also of ceramic.

In accordance with my invention, the upper or anode portion of the envelope is provided with a massive annular ceramic member 26 fluted longitudinally at 28 and having coated on the inside thereof a thin metallized coating 29 which forms the anode of the tube. A coating of .0001" which may be a deposit of molybdenum will have an electrical resistance of .006 ohm which is adequate for handling several amperes of current. The form of the anode shown is easily and cheaply made and extremely accurate by pressing or extruding the ceramic part. These are advantages over anodes fabricated of metal. In addition, this construction has fewer parts and eliminates the problem of thermal expansion differences developing strains in a metal to ceramic vacuum type seal passing large heat currents which result when a metal anode is separately supported by, for example, a flange sealed to or through the envelope wall.

The upper end of the envelope is closed by a cup-shaped member 30 in turn sealed to the anode portion 26 of the envelope. Within the cup-shaped closure member 30, I mount a second cup-shaped member 31 provided with dependent fingers 32 preferably three in number which extend into the flutes 28 of the anode portion 26 of the envelope to properly position the closure member 30 during sealing operations.

The cap 30 is sealed to anode portion 26 of the envelope after bakeout and exhaust at high temperatures to degas the tube. The bakeout temperature is below the temperature of the sealing metal which may be in the form of a ring, the ring being placed between the flange 30' of the cap 30 and the metallized portion of the anode. After bakeout and exhaust in an exhaust machine, the seal is made by heating the brazing or soldering ring (not shown) to its brazing or soldering temperature.

The portions of the envelope that are sealed to each other and to the lead-ins, and the closure cap may be sealed together by applying a molybdate solution to the surface and metallizing it to provide a surface on the ceramic to which the parts may be sealed during manufacture.

The base portion of the envelope is provided with a tapered collar 35 having preferably a filling of solder

36 or a brazing material of higher melting point to provide a heat transfer arrangement between the lower portion 25 of the envelope and the header member 10 so that the heat can be transferred efficiently to a properly formed socket 37 connected to a heat sink panel 38.

The inner wall of the member 25 may be coated at 33 to provide, with the screen grid and flange 18, a further shielding between anode and control grid which is electrically connected to ground by the heat sink connection.

The relationship of the cathode, anode and control grids and side rods is shown in greater detail in FIG. 3. It will be noted that the side rods 21' of the control grid 21 which are mounted outside of the laterals of the grid 21 and the side rods 22' of the screen grid 22 are in alignment and positioned centrally of the flutes 28. This permits very close spacing of the control grid to the cathode giving a high transconductance. The spacing can be made less than the diameter of a side rod. By positioning the side rods 21' and 22' in alignment with the middle of the flutes, the spacing between the side rods and the electron receiving portions of the anode is a maximum, thus decreasing interelectrode capacity and increasing the breakdown voltage path.

To explain the advantages of a tube made according to my invention, reference is made first to FIGS. 4 to 7, inclusive.

In FIG. 4 there is shown in longitudinal section, partially in schematic, one form of one of my previous designs of electron discharge device having a heat circuit which does not provide the advantages that my present invention does for a high power low temperature tube of small size and close spacings. This tube comprises an envelope having a header member 40 having the usual lead-ins 41 for supporting the electrodes within the envelope. The envelope includes an annular member 42 closed at one end by header 40. The upper end is closed by a member including a collar 43 having a support flange 44 for supporting the anode 45 within the envelope, and the metallic cup-shaped member 46. In the arrangement shown, the anode 45 may be of steel. The header 40 and annular portion 42 which may be of Fosterite. A flange collar member 47 fixed to the envelope connects the tube to the supporting chassis and heat sink 48.

The temperature rise ΔT between the heat sink 48 and the anode 45 is given in degrees centigrade at ΔT is equal to R times P_a where R is thermal resistance and P_a the heat current which is equal to the electrical power dissipated at the anode.

In FIG. 5 it will be observed that the temperature differences exist between the metal parts and ceramic shell. This causes expansion and mechanical stresses at the seal joints and possible displacement of the anode. An anode temperature of 430° C. results with an 18 watt plate dissipation. This temperature, while common in power tubes of conventional types, that is of large sizes and conventional cooling means, is not low enough for high reliability because such temperature may free occluded gas. Further, a power dissipation of 18 watts is not sufficient for adequate utilization of the electrical capacities of the tube.

On the other hand, the heat circuit of a tube made according to my invention and shown schematically in section in FIG. 6, has a considerably lower resistance than the tube shown in FIG. 4 and provides a plate temperature of only 159° C. for an 18 watt heat flow. Even for 60 watt heat flow, the plate temperature will not exceed 390° C. This dissipation is much higher than needed for use of the tube in horizontal deflection service for color television receivers. One of the reasons for this much reduced temperature of the anode for the same power dissipation results from the fact that the ceramic anode forms part of the shell with the anode proper in direct contact with the ceramic part. The heat flows through the portion 26, portion 25, and to the collar 35 to socket shell 37 and heat sink 38. Since the plate cap

carries very little heat current, no strains, or substantially no strains result on its seal to the anode body 26 which is at substantially the same temperature as the plate cap.

In FIG. 8 I show a modified form for connection to a heat sink for transmitter and modulator service. The tube is connected to a heat sink 50 by means of a clamp 51 which is directly secured to the insulated anode portion 26 of the tube envelope. In this case the thermal resistance between the clamp and anode electrode is reduced to 1 ohm. A power dissipation of 200 watts will thus produce only a 200° C. rise above the heat sink temperature. Thus, tubes having a diameter of only 1" and a height of 1¼" are capable of working with a 1000 volt anode at a plate dissipation of 200 watts and supplying peak currents in the order of 1 ampere.

By making the ceramic of berylia, the thermal resistance can be reduced to ¼₁₀ of an ohm resulting in an almost cold anode, that is, a rise of 25° C. above the heat sink temperature with ¼ kw. dissipation.

I have an anode and shell combination which provides a low resistance heat path and low capacity to a grounded heat sink. This is made possible by using a thick walled envelope on the inner wall of which is the anode electrode and by properly shaping the envelope.

I provide a thermal anode circuit which prevents heating of the other elements, particularly the grid, by heat from the anode because I have interposed a heat sink connection (grounded) between the thermal anode circuit and the thermal circuits of the other elements.

Referring to FIGURE 1, the heat flow lines are shown by the dotted lines as directed radially outwardly through a rapidly increasing cross section, to the thick wall shell portion 25, through the heat transfer collar connection 35 and solder filler 36 to the socket or connecting collar 37 forming part of the socket 60 having prongs 61, to the heat sink 38. This provides a heat circuit having very low thermal resistance. Any heat in the various leads is conducted off through the socket contacts or headers 10.

It will be observed that the thermal circuits from the anode and from the other electrodes on the header are isolated from each other. Both go to the heat connecting collar 37 to the heat sink. Thus, the heat generated at the anode cannot reach the other electrodes supported on the header 10, thus improving the tube's desirable characteristics.

In addition to the above, I not only provide a good grounded heat connection, but I provide a simultaneous heat and electrical connection to a socket of the plug in types insuring good heat conduction when the tube is put into an operating socket so that the tube cannot be operated at high temperatures.

Referring now specifically to FIG. 3, the anode portion 26 of the envelope, as previously described, is provided with a plurality of longitudinally extending flutes 28. The side rods 21' and 22' of the control grid 21 and screen grid 22 are in alignment and register with the middle of the flutes. The portions 28' of the envelope between the flutes 28 form the working surfaces of the anode for receiving the main anode current. It will be observed that the side rods result in producing a plurality of radially directed beams directed toward the portions 28' of the anode. In conventional electrode systems, it is well known to provide a proper critical spacing for predetermined current densities between the screen grid and the anode to develop a space charge as shown at 28'' between these two electrodes for suppressing secondaries from the anode surfaces. However, the electron density of the beams adjacent the side rods is less than that in the mid portion of the beam. Poor suppressor action in these outer portions results with the danger that secondaries will get back to the screen grid unless some provision is made to counteract this effect.

In accordance with my invention, I make the portions 28' of smaller transverse dimensions than the transverse

dimensions of the electron stream. As a result, those portions of the electron stream of each beam where the electrons are less dense, enter into the flutes 28 as indicated by the arrows. In addition to capturing most of the primaries, a space charge is set up inside of the flutes as at 28''' for suppressing any secondaries that may be knocked out of the anode at the bottom of the flute. In this way I obtain space charge suppression even though the beam is less dense at its outer portions. This is because a space charge can be formed even with a less dense beam if the path of travel is lengthened to the necessary critical distance between the anode and the screen grid. These novel features of secondary emission suppression and of low interelectrode capacity and long breakdown paths can be utilized in tubes other than the specific tube disclosed in FIG. 1.

What is claimed is:

1. An electron discharge device having a ceramic envelope including a relatively massive annular anode portion having a relatively thick wall, and a second annular portion abutting said anode portion and having a relatively thick wall the outer diameter of which is equal to the outer diameter of said anode portion but having a larger inner diameter than said anode portion, a relatively thin metallic surface on the inner wall of said anode portion providing an anode electrode, a ceramic closure member sealing the end of said second annular portion with a vacuum tight fit, terminal leads and supports extending through said closure member, electrode means supported by said closure member and leads within the anode electrode, and a conducting collar extending along the outside wall of said envelope from said closure member towards said anode portion and being in heat conducting relationship with said envelope for providing a heat transfer member whereby heat is conducted laterally outwardly from said anode electrode and longitudinally to said second annular portion and to the heat transfer collar along a heat circuit of low thermal resistance, said conducting collar being adapted to connect to a heat sink to remove heat rapidly from said electron discharge device.

2. An electron discharge device having a ceramic envelope including a relatively massive annular anode portion having a relatively thick wall, and a second annular portion abutting said anode portion and having a larger inner diameter than said anode portion, a relatively thin metallic coating on the inner wall of said anode portion providing an anode electrode, a ceramic closure member sealing the end of said second annular portion with a vacuum tight fit, terminal leads and supports extending through and sealed in said closure member, electrode means supported by said closure member and leads within the anode electrode, and a conducting collar extending along the outside wall of said envelope from said closure member towards said anode portion and being tapered outwardly from said header member said collar being in heat conducting relationship with said envelope for providing a heat transfer element whereby heat is conducted from said anode electrode through the walls of said envelope to said heat transfer collar along a heat circuit of low thermal resistance, said conducting collar being adapted to be connected to a heat sink for rapidly removing heat from said electron discharge device.

3. An electron discharge device having a ceramic envelope including a relatively massive annular anode portion having a relatively thick wall, and a second annular portion abutting said anode portion and having a relatively thick wall but having a larger inner diameter than said anode portion, a metallic surface on the inner wall of said anode portion providing an anode electrode, a ceramic closure member sealing the end of said second annular portion with a vacuum tight fit, terminal leads and supports extending through and sealed in said closure member, electrode means supported by said closure mem-

ber and leads within the anode electrode, and a conducting collar extending along the outside wall of said envelope from said closure member towards said anode portion and being in heat conducting relationship with said envelope for providing a heat transfer element whereby heat is conducted from said anode electrode through the envelope walls to the heat transfer collar along a heat circuit of low thermal resistance, said conducting collar being adapted to be connected to a heat sink for rapidly removing heat from said electron discharge device.

4. An electron discharge device having a ceramic envelope including a relatively massive annular anode portion having a relatively thick wall, and a second annular portion abutting said anode portion and having a relatively thick wall but having a larger inner diameter than said anode portion, a metallic surface on the inner wall of said anode portion providing an anode electrode, a ceramic closure member sealing the end of said second annular portion with a vacuum tight fit, terminal leads and supports extending through and sealed in said closure member, electrode means supported by said closure member and leads within the anode electrode, and a conducting collar extending along the outside wall of said envelope from said closure member towards said anode portion and being in heat conducting relationship with said envelope for providing a heat transfer element whereby heat is conducted from said anode electrode through the envelope walls to the heat transfer collar along a heat circuit of low thermal resistance, a heat sink having a collar the inside surface of which conforms to the collar on said electron discharge device, the heat sink collar receiving the collar on said electron discharge device in physical and heat conducting relationship.

5. An electron discharge device having a ceramic envelope including a relatively massive annular anode portion having a relatively thick wall, and a second annular portion abutting said anode portion and having a relatively thick wall but less thick than said anode portion and having a larger inner diameter than said anode portion, a metallic surface on the inner wall of said anode portion providing an anode electrode, a ceramic closure member sealing the end of said second annular portion with a vacuum tight fit, terminal leads and supports extending through and sealed in said closure member, electrode means supported by said closure member and leads within the anode electrode, and a conducting collar surrounding the outside wall of said envelope and in heat conducting relationship with said envelope for providing a heat transfer element whereby heat is conducted outwardly from said anode electrode through the ceramic wall of said envelope to said heat transfer collar along a heat circuit of low thermal resistance, said conducting collar being adapted to be connected to a heat sink for rapidly removing heat from said electron discharge device.

6. An electron discharge device having a ceramic envelope including a relatively massive annular anode portion having a relatively thick wall, and a second annular portion abutting said anode portion and having a relatively thick wall but less thick than said anode portion and having a larger inner diameter than said anode portion, a metallic surface on the inner wall of said anode portion providing an anode electrode, a ceramic closure member sealing the end of said second annular portion with a vacuum tight fit, terminal leads and supports extending through and sealed in said closure member, electrode means supported by said closure member and leads within the anode electrode, and a conducting collar surrounding the outside wall of said envelope and in heat conducting relationship with said envelope for providing a heat transfer element whereby heat is conducted outwardly from said anode electrode through the ceramic wall of said envelope to said heat transfer collar along a heat circuit of low thermal resistance, a heat sink having a collar the inside surface of which con-

forms to the collar on said electron discharge device, the heat sink collar receiving the collar on said electron discharge device in physical and heat conducting relationship.

7. An electron discharge device having a ceramic envelope including a relatively massive annular ceramic member providing a portion of the envelope wall, a metallic surface on the inner wall thereof for providing an anode electrode, a conducting closure member mounted at one end of said ceramic member with a vacuum tight fit and electrically connected to said metallic surface providing an anode terminal, a second annular ceramic member abutting said relatively massive ceramic member and forming another portion of the envelope wall, a ceramic header member sealing the end of said second ceramic member with a vacuum tight fit, electrode means supported by said header member to extend within said relatively massive annular ceramic member, and a conducting collar surrounding said header member and said second annular ceramic member and in heat conducting relationship with said envelope for providing a heat transfer member for heat conducted through the ceramic envelope to a heat sink.

8. An electron discharge device having a ceramic envelope including a relatively massive annular ceramic member providing a portion of the envelope wall, a metallic surface on the inner wall thereof providing an anode electrode, a conducting closure member mounted at one end of said ceramic member with a vacuum tight fit and electrically connected to said metallic surface for providing an anode lead, a ceramic closure member sealing the other end of said envelope with a vacuum tight fit, and electrode means supported by said ceramic closure member to extend within said anode electrode, and a conducting collar surrounding said envelope and in heat conducting relationship therewith for providing a heat transfer member for heat conducted from said anode electrode to a heat sink, said envelope providing a heat circuit of low thermal resistance.

9. An electron discharge device having a ceramic envelope including a relatively massive annular anode portion having a relatively thick wall and fluted on the inside, a relatively thin metallic coating on the fluted inner wall of said anode portion providing an anode electrode, said envelope including a second annular portion abutting said anode portion and having a relatively thick wall and having a larger inner diameter than said anode portion, a ceramic closure member sealing the end of said second annular portion with a vacuum tight fit, terminal leads and supports extending through and sealed in said closure member, electrode means supported by said closure member and leads within the anode electrode, said electrode means comprising coaxial cathode and grid electrodes, said grid electrodes having aligned parallel side rods, said side rods registering with the middle of said fluted portions of said anode portion, and a conducting collar extending along the outside wall of said envelope from said header member towards said anode portion and being in heat conducting relationship with said envelope for providing a heat transfer element between said electron discharge device and a heat sink whereby heat is conducted from said anode electrode through said ceramic envelope to the heat transfer collar along a heat circuit of low thermal resistance.

10. An electron discharge device having an envelope enclosing a cylindrical cathode, a plurality of grids coaxial therewith and each having spaced longitudinally extending side rods, an anode surrounding said cathode and grids and having a plurality of flutes extending longitudinally of the anode, the side rods of said grids being in alignment and registering with the mid-portion of said flutes, there being one flute for each pair of aligned and registering side rods the anode portion between said flutes being narrower than the space between adjacent pairs of said aligned side rods whereby during operation

of said tube said side rods form electrons from said cathode into a plurality of radially directed beams the outer portions only of which are directed into said flutes, the spacing between the grid next to said anode and the anode portions between said flutes being such as to provide a space charge between said last-mentioned grid and said anode portions for suppression of secondary electrons.

11. An electron discharge device having an envelope enclosing a cylindrical cathode, a control grid and a screen grid each coaxial with said cathode, said grids having spaced longitudinally extending side rods, an anode within said envelope surrounding said cathode and grids and having a plurality of radially directed flutes extending longitudinally of the anode, the side rods of said grids being in alignment and registering with the middle of said flutes, there being one flute for each pair of aligned and registering side rods the anode portion between said flutes being narrower than the space between adjacent aligned side rods whereby during operation of said tube said side rods form electrons from said cathode into a plurality of radially directed beams the outer portions only of which are directed into said flutes, said grids having laterals mounted on the side of said side rods towards said cathode whereby said control grid may be spaced a distance less than the diameter of said side rods, the spacing between said screen grid and the anode portions between said flutes being such as to provide a space charge between said screen grid and said anode portions for suppression of secondary electrons.

12. An electron discharge device having a first annular ceramic member providing a portion of the envelope wall, a metallic surface on the inner wall thereof for providing an anode electrode, a closure member mounted at one end of said ceramic member with a vacuum tight fit, a second annular ceramic member having one end abutting said first annular ceramic member with a vacuum tight contact and forming another part of the envelope wall, a ceramic closure member sealing the other end of said second ceramic member with a vacuum tight fit and electrode means supported by said ceramic closure member to extend within said first annular ceramic member, and a conducting collar surrounding and in contact with said second annular ceramic member and said ceramic closure member to provide a heat transfer member between said electron discharge device and a heat sink.

13. An electron discharge device having a first annular ceramic member providing a portion of the envelope wall, a metallic surface on the inner wall thereof for providing an anode electrode, a closure member mounted at one end of said ceramic member with a vacuum tight fit, a second annular ceramic member having one end abutting said first annular ceramic member with a vacuum tight contact and forming another part of the envelope wall, a ceramic closure member sealing the other end of said second ceramic member with a vacuum tight fit and electrode means supported by said ceramic closure member to extend within said first annular member, and a conducting collar surrounding and in contact with said ceramic envelope to provide a heat transfer member between said electron discharge device and a heat sink.

14. An electron discharge device having a cylindrical ceramic envelope including an anode portion having a relatively thick wall and an inner diameter less than the other portions of said envelope, a ceramic header member closing the end of said envelope opposite said anode portion, a plurality of leads and supports extending through said header member, a plurality of supporting flanges supported in spaced relationship upon said lead-ins within said envelope, said supporting flanges being of increasing diameter from said header to the anode portion of said envelope, a plurality of coaxial electrodes supported in said flanges, the inner wall of the anode portion of said envelope having a metallic surface thereon to provide an anode, said electrodes being within and coaxial with said anode, the anode portion of said envelope being closely

adjacent to the outermost electrode supported by said flanges, and a conducting collar surrounding and in contact with said ceramic envelope to provide a heat transfer member between said electron discharge device and a heat sink.

15. An electron discharge device having an envelope enclosing a cylindrical cathode, a control grid and a screen grid surrounding and coaxial with said cathode, each of said grids having longitudinally extending side rods, an anode surrounding said cathode and grids and having a plurality of outwardly and radially extending flutes longitudinally of the anode, the side rods of said grids being in alignment and registering with the middle of said flutes, there being one flute for each pair of aligned and registering side rods the anode portion between said flutes receiving electrons from said cathode being narrower than the space between adjacent pairs of said aligned side rods whereby during operation of said tube said side rods form electrons from said cathode into a plurality of radially directed beams the outer portions only of which are directed into said flutes, the spacing between said screen grid and the anode portions between said flutes being such as to provide a space charge between said screen grid and said anode portions for suppressing secondary electrons.

16. An electron discharge device having an envelope enclosing a cylindrical cathode, a control grid and a screen grid surrounding and coaxial with said cathode, said grids having longitudinally extending side rods, an anode surrounding said cathode and grids and having a plurality of outwardly and radially extending flutes longitudinally of the anode, the side rods of said grids being in alignment and registering with the middle of said flutes, the anode portion between said flutes receiving electrons from said cathode being narrower than the space between adjacent pairs of said aligned side rods whereby during operation of said tube said side rods form electrons from said cathode into a plurality of radially directed beams the outer portions only of which are directed into said flutes, the distance between said screen grid and the anode portions between said flutes being such as to provide a space charge therebetween for suppressing secondaries, electrons entering said flutes providing a space charge within said flutes during operation of said electron discharge device.

17. An electron discharge device having a ceramic envelope including an anode portion, and a header member closing one end of said envelope, a plurality of leads and supports extending through said header member, the inner wall of the anode portion of said envelope being fluted and having a conducting surface thereon to provide an anode electrode, said leads supporting electrode means within said anode portion of said envelope and a closure member for the end of said anode portion opposite said header member and having means extending therefrom and into the flutes of said anode portion for positioning said closure member.

18. An electron discharge device having a ceramic envelope, said envelope including an anode portion having a relatively thick wall and an inner diameter less than the other portions of said envelope, a conducting surface on the inner wall of said anode portion providing an anode electrode, and a header member closing the end of said envelope remote from said anode portion, said header member being bonded to said envelope by a metallic bond extending through the envelope, a plurality of leads and supports extending through said header member, a plurality of flanges of increased diameter supported in spaced relationship upon said lead-ins, said supporting flanges being of increasing diameter in a direction of the anode portion of said envelope, a cathode electrode, control grid electrode and screen grid electrode supported on said flanges in coaxial relationship within said anode electrode and coaxial therewith, a conducting surface on the inner wall of said envelope extending from said header to ad-

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jacent the flange supporting said screen grid and electrically connected to said metallic bond, a conductive collar surrounding said header and said envelope and in heat conducting relationship therewith and connected to said metallic bond, said collar serving as a heat transfer member between said anode electrode and a heat sink and as a grounding contact for the conducting surface electrically connected to said metallic bond.

19. An electron discharge device having an envelope including a relatively massive annular ceramic anode portion having a relatively thick wall and a second annular portion abutting said anode portion and having a larger inner diameter than said anode portion, a metallic surface on the inner wall of said anode portion providing an anode electrode, a closure member sealing the end of said second anode portion with a vacuum tight fit, terminal leads and supports extending through and sealed in said closure member, electrode means supported by said closure mem-

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ber within said anode electrode, and a conducting collar surrounding the outside wall of said envelope and in heat conducting relation with said envelope for providing a heat transfer element whereby heat is conducted outwardly from said anode electrode through the ceramic wall of said envelope to said heat transfer collar along a heat circuit of low thermal resistance, said heat transfer collar being adapted to cooperate with a heat sink having means for contacting said collar on said electron discharge device in physical and heat conducting relationship.

References Cited in the file of this patent

UNITED STATES PATENTS

2,254,095	Thompson	Aug. 26, 1941
2,569,847	Eitel et al.	Oct. 2, 1951
2,647,218	Sorg et al.	July 28, 1953
2,814,750	Polese	Nov. 26, 1957