Dec. 14, 1948. E. K. SMITH 2,456,540

ELECTRODE STRUCTURE FOR ELECTRON DISCHARGE TUBES

Filed June 7, 1946 2 Sheets-Sheet 1

FIG. 1.

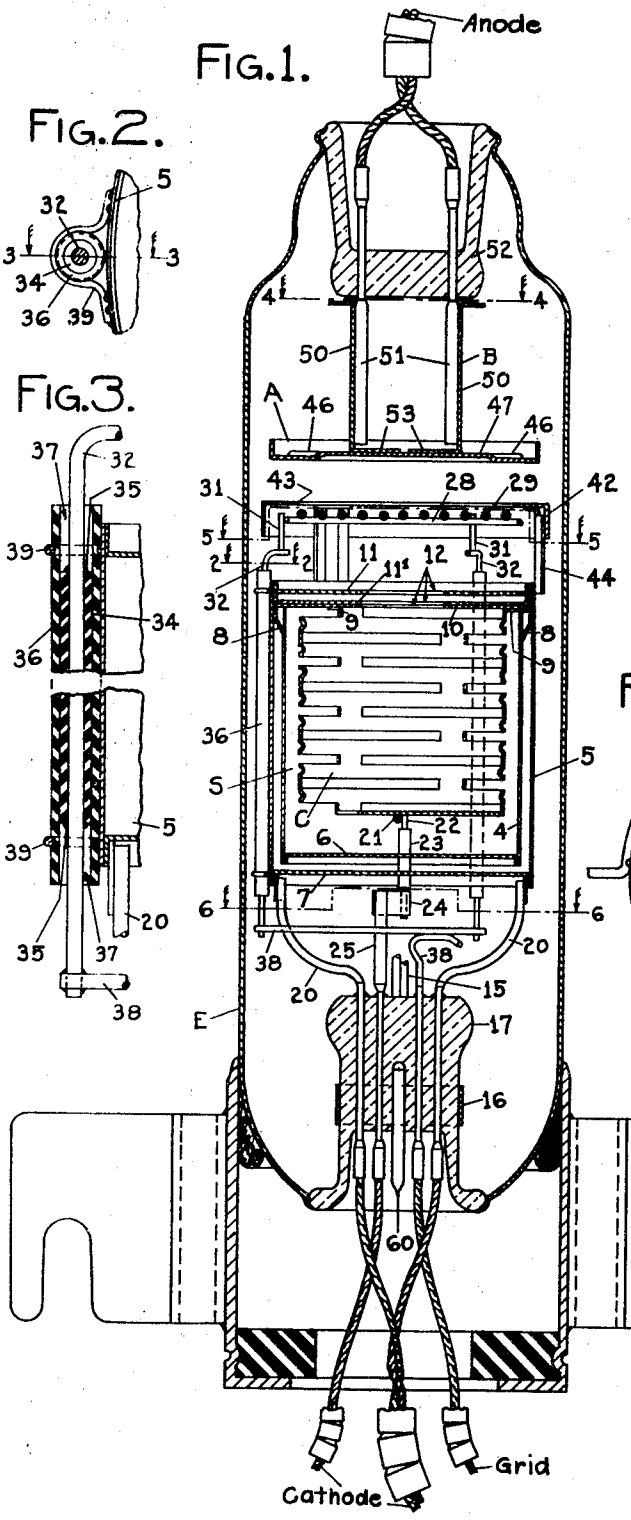


FIG. 2.

FIG. 3.

FIG. 4.

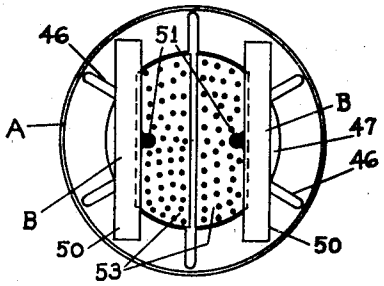


FIG. 5.

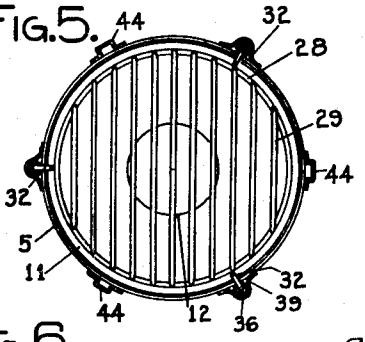
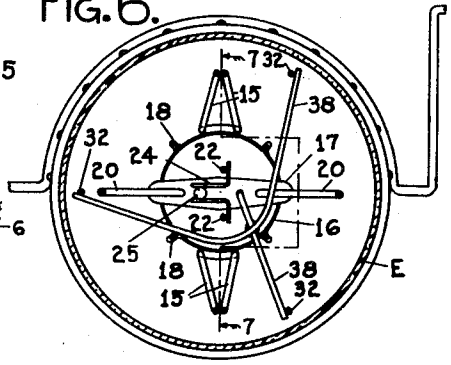


FIG. 6.



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ELECTRODE STRUCTURE FOR ELECTRON DISCHARGE TUBES

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FIG. 7.

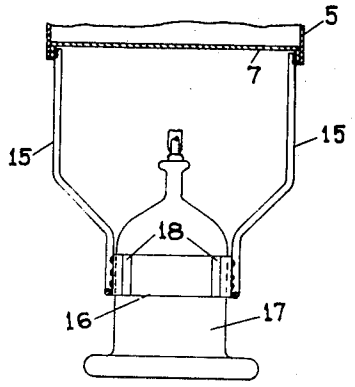


FIG. 8.

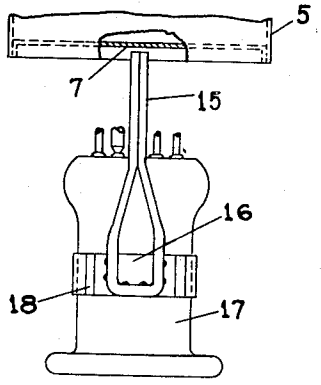


FIG. 9.

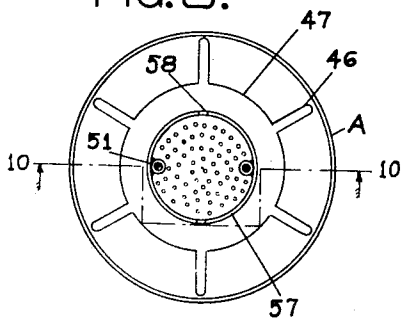


FIG. 11.

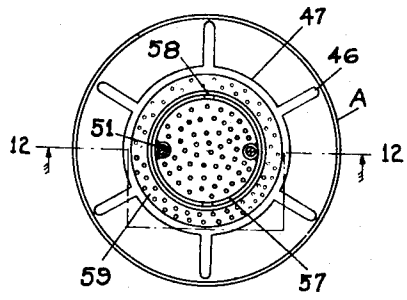


FIG. 10.

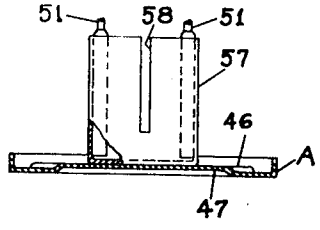
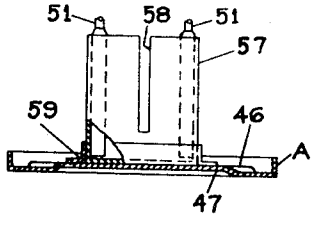


FIG. 12.



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Patented Dec. 14, 1948

2,456,540

UNITED STATES PATENT OFFICE

2,456,540

ELECTRODE STRUCTURE FOR ELECTRON DISCHARGE TUBES

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Application June 7, 1946, Serial No. 674,953

19 Claims. (Cl. 250—27.5)

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This invention relates to controllable electron discharge devices and more particularly to gaseous discharge tubes of the grid control type.

In grid control gas tubes, such as exemplified for example in our prior Patent No. 2,068,539, of January 19, 1937, it is important that the anode, grid, and the cathode with its heat shield, should be rigidly supported in the tube envelope, and yet be effectively insulated from each other, so that the tube will withstand the severe shocks and vibration to which tube may be subjected in operation, without injury to the supporting structures or disturbance in the position and relationship of the tube elements. In tubes of this type, it is convenient to support the cathode and heat shield on supports sealed in one end of the envelope, and mount the anode on a support sealed in the opposite end of the envelope, such an arrangement affording a high degree of electric isolation for these electrodes and the desired rigidity in their support. The mounting and supporting of the control grid, however, in the proper relationship to the anode and cathode heat shield, with adequate insulation with respect to these tube element, and with sufficient rigidity to withstand shock and vibration, presents difficulties in the structural arrangement and organization of the parts.

One object of this invention is to provide an improved form of grid supporting and insulating structure for electron discharge tubes, more particularly grid control gas tubes.

Generally speaking, and without attempting to define the nature and scope of the invention in this regard, it is supposed to support the grid by a plurality of supporting elements anchored directly to the cathode heat shield to obtain the desired stiffness or rigidity, and to employ a type of insulating means for these supports, which in addition to being readily degassed and having the requisite insulating properties, is specially formed to avoid breakdown by surface leakage.

Considering another feature of this invention, it is expedient to employ tantalum as the material for anodes of electron discharge tubes, on account of certain desirable attributes; but there are certain disadvantages in use of tantalum where the anode may assume a high temperature in operation, as in power tubes and gas discharge tubes of high current rating. Among other things, tantalum is a relatively poor conductor and radiator of heat, and may become overheated in localized areas and cause objectionable emission. Also, the weld of tantalum to a metal like nickel conveniently employed in

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mounting tube structures, does not stand up reliably under high temperatures; and a support of a material suitable for welding strength, as well as heat dissipation, is desirable for supporting tantalum anodes for high current densities.

In view of these considerations, a further object of this invention is to provide an improved form of anode structure which will have reliable welding strength, and afford the desired facilities for heat conduction and radiation to permit a tantalum anode to operate at an acceptable temperature for high current densities.

Generally speaking, and without attempting to define the nature and scope of the invention in this respect, it is proposed to weld heat conducting and radiating elements of a ferrous metal to a tantalum anode, so that the anode is adequately supported, and so that heat will be conducted and radiated from the extensive area of the anode to obviate localized overheating of the anode.

Various other objects, characteristic features, attributes and advantages of the invention will be in part apparent, and in part pointed out as specific embodiments of the invention are described.

In describing the invention, it is convenient to refer to the accompanying drawings, in which is illustrated certain specific structures embodying the invention, and in which like reference characters are used to designate like parts in the several views.

In these drawings, Fig. 1 is a general longitudinal section along the axis of one form of a tube embodying the invention.

Fig. 2 is an enlarged fragmentary section taken along the line 2—2 in Fig. 1, to illustrate the details of the grid supporting structure.

Fig. 3 is a longitudinal section through one of the insulating tubes for a grid support along a line indicated at 3—3 in Fig. 2 and parallel with the axis of the tubes.

Figs. 4, 5 and 6 are transverse sections through the tube taken along the lines 4—4, 5—5 and 6—6 in Fig. 1.

Fig. 7 is a fragmentary sectional view on the line 7—7 in Fig. 6 to illustrate the collar on the stem of the glass envelope constituting the support of the cathode and heat shield.

Fig. 8 is another fragmentary view of the structure shown in Fig. 7 from another side.

Figs. 9 and 10 illustrate modified forms of the anode structure; and

Figs. 11 and 12 illustrate a still different specific form of the anode structure.

Considering the specific tube structure illustrated in Fig. 1 of the drawings, the cathode C is of the slotted cylindrical type, such as shown in our prior patent, No. 2,115,506, March 15, 1938. In brief, this cathode C comprises a thin sheet of nickel formed with slots and corrugated for stiffness, which is rolled and welded into a cylindrical form with the slots extending transversely, so that current flows from one end of the cathode to the other over a zig-zag path, so to speak, to heat the cathode. This cathode is coated on the inside surface with a highly emissive oxide coating, preferably formed and treated in a manner disclosed in our prior Patent No. 2,281,864, May 25, 1937.

The cathode C is surrounded by a cylindrical heat shield, designated as a whole S, which is formed of inner and outer cans 4, 5 of thin sheet nickel to form a double-walled heat shield. In the specific arrangement shown, these heat shield cans 4, 5 are provided at the bottom with end pieces 6, 7 having flanges seam-welded to the side walls of the cans. The inner heat shield can 4 is formed at the top with a plurality of lugs 8, stamped and bent out from the side walls and welded to the outer heat shield can 5 to support the inner can 4 in the proper space relation.

The upper edge of the cathode C is formed with three radially projecting tabs 9 to which is welded an annular disc 10 for the purpose of stiffness; and the ends of these tabs 9 are bent up and welded to the inner surface of the outer heat shield can 5 at its upper end, so that the cathode is electrically connected at its upper end to the heat shield S. The upper end of the outer heat shield can 5 is provided with two spaced flanged end pieces 11, 11^1, welded thereto and each having a circular discharge opening therein indicated at 12. The annular disc 10 has a similar circular discharge opening therein.

The cathode C and heat shield S are rigidly supported in a suitable glass envelope E of the usual type by two stiff bifurcated uprights 15, which are welded at their upper ends to the bottom edge of the outer heat shield cans (see Figs. 7 and 8), and at their lower ends to a collar 16 on a reentrant stem 17 of the tube envelope. The collar 16 is crimped to form a plurality of folded projecting ridges 18 which may be squeezed together to clamp the collar 16 tightly on the glass stem 17, and yet permit expansion and contraction of the collar under temperature changes without loosening it on said stem.

The cathode heat shield assembly S is also provided with connecting rods 20 welded at their upper ends to tabs on the bottom of the heat shield can 5 (see Fig. 1), and these rods 20 are bent and anchored in seals in the press of the reentrant stem 17 as shown in Fig. 1, the portion of these rods passing through the glass seal being of an appropriate material to provide a gas-tight seal. These cathode connecting rods 20 may be connected to suitable leads as shown.

The lower end of the cathode C is formed with a cross member 21 (see Fig. 1) welded to the upper end of two rods 22 which pass inside of insulated sleeves 23 of a suitable ceramic insulating material, such as commonly known as steatite, through holes in the bottom ends 6, 7 of the heat shield cans 4, 5. The lower ends of these rods 22 are connected by welded members 24 to a rod 25 (see Fig. 6), and this rod 25 is sealed in the stem 17 to provide an external connection to the lower end of the cathode C. It can be readily seen that current will flow from one cathode lead-in support 25 to the lower end of the cathode C, through the turns or convolutions of the cathode, and thence out at its upper end to the heat shield S and the two connecting rods 20.

In the tube structure shown, the control grid (see Figs. 1 and 5) comprises a Nichrome ring 28 to which is welded a plurality of spaced grid bars 29 to form a type of grid such as disclosed in our prior Patent No. 2,068,539, January 19, 1937. The grid bars 29 are preferably treated in the manner disclosed in our prior Patent No. 2,012,339, August 27, 1935, to reduce emission from the grid.

The control grid assembly 28, 29 is supported above the end of the heat shield S, in the position shown in Fig. 1, by a plurality of supporting elements (three as shown), each of which comprises a short connector 31 welded to the grid ring 28 and to the bent upper end of a stiff supporting rod 32 which passes through an insulating element attached to the heat shield S.

Considering more in detail this grid supporting and insulating structure, which constitutes the important feature of this invention, and referring to Figs. 2 and 3, each of the grid supporting rods 32 extends through an inner tube or sleeve 34; and after assembly this rod 32 is enlarged near the ends of this tube, as indicated at 35 by a welding or pressing operation, to form shoulders engaging the end of the tube 34, so that the tube 34 may not slide up or down on the rod 32 too much out of its proper position. This inner tube 34 is fitted inside a longer outer tube 36, leaving a deep cylindrical cavity or recess, as indicated at 37 at each end. The fit of the grid supporting rod 32 in the inner insulating tube 34, and the fit of this inner tube 34 in the outer insulating tube 36, is as tight or snug as the manufacturing tolerances for tubes of steatite material and ready assembly will permit. The outer tube 36 is formed with shallow grooves near its ends and is firmly anchored to the outer surface of the heat shield S by wires or strips 39 seated in these grooves and welded to the heat shield S.

The inner and outer tubes 34, 36 are made of a material which has adequate insulating properties, is not adversely affected by high temperature, and is susceptible of being readily degassed. For this purpose, it is preferred to employ some one of the ceramic materials commonly known as steatite. Since this kind of material may be conveniently and economically extruded in tubular form, one suitable arrangement is to employ inner and outer tubes in the manner shown, although for many applications of the invention each insulating element may be in the form of a single tube having the appropriate recess or cavity 37 in each end.

The cavity or recess 37 in the ends of the insulating elements is a significant feature of this structure.

In tubes of the type under consideration, the heat shield cans and the various supporting elements and welded connections are preferably made of nickel; and when these parts are heated to the high temperatures desirable to carry out a complete degassing process and treatment for the emissive coating for the cathode, there is a certain degree of vaporization of the nickel and other metal parts which tends to deposit minute quantities of a metallic conducting material on the surfaces of any insulating element inside the tube. Also, in the normal operation of the tube there is likely to be a certain amount of sputtering of conductive material from the anode and cathode by electronic or ionic bombardment,

which tends to deposit or accumulate on the surfaces of any insulating element that may be used in the tube.

Such vaporization or sputtering of conductive material inside the tube envelope occurring during fabrication or in operation tends to accumulate on all exposed insulating surfaces; and if the insulating sleeve or bushing, such as proposed for the grid supporting rod **32**, should have an ordinary flat or curved end surface around the supporting rod, it is found that conductive material is likely to accumulate on exposed surfaces of the insulated sleeve to a degree that there is sufficient surface leakage to destroy the high insulation resistance required for the proper functioning of the grid. However, if each end of this insulated sleeve or bushing for the grid supporting rod is formed with a recess or cavity of the appropriate form and dimensions, such as the recess **37** provided in the structure illustrated and described, it is found that the evaporated or sputtered conducting material is not deposited on the surfaces of the insulating sleeve with sufficient density and continuity to interfere with the high degree of grid insulation desired.

The advantageous results of such a structural arrangement may be attributed to the protective or shielding effect provided for parts of the surface of the recess **37** against the deposit of vaporized or sputtered conductive material, when the depth of this recess is appropriately proportioned with respect to the width of the annular space around the grid supporting rod **32**. It is probable that this evaporated or sputtered material tends to follow a direct and approximately straight line path in its movement from its source, since shadows formed by obstructing parts may be observed in the deposit of such material on the walls of the tube envelope. Assuming that evaporated or sputtered material tends to follow a definite path in its movement from the source, it can be seen that, if this path is at an angle to the axis of the recess, such material cannot reach the bottom and lower portions of the walls of the recess, if this recess is of sufficient depth with respect to the annular opening through which this material must pass. It is also possible that the lack of collimation effect upon vapor streams may be a factor in obviating the deposit of conducting material where the depth of the annular recess or column is large as compared with its width.

In this connection, it can be appreciated that any interruption in the continuity of a film of conductive material over the surface of the recess which obviates a complete conductive path between the grid supporting rod **32** and the heat shield S will afford the desired degree of insulation, regardless of the density of the film of conductive material on other parts of the exposed surfaces of the insulating sleeve or its recess. In other words, the outer circumferential surface of the outer insulating sleeve **36** and its exposed ends may accumulate a relatively heavy deposit of conductive material without interfering with the insulation of grid, provided the walls or end surfaces of the recess do not also accumulate a film of conductive material of a continuity and density sufficient to constitute a surface leakage path. From this point of view, the use of separate inner and outer tubes for the grid insulating element in the manner shown may be said to be helpful because the small crack or separation necessarily existing between these tubes at the bottom of the recess for a substantial part of its circumference will constitute a break in the deposit or film of conductive material in the recess that will reduce the probability of the formation of a complete conducting path between the rod **32** and the heat insulating cans.

Since the sources of evaporated or sputtered conductive material existing during fabrication or operation of the tube, and the paths for movement of such material will be different in different tube structures, the shape and relative proportions of a recess, such as the recess **37**, in the grid insulating element for satisfactory results is subject to considerable variation. The results obtained by such a recess structure may be attributed to different theories or effects; but generally speaking the purpose of this recess in accordance with this invention is to afford a protective or shielding effect against accumulation of a continuous film of evaporated or sputtered material on the surfaces of this recess, as distinctive from mere increase in area, so that there is no accumulation of conductive material of a density and continuity to provide a surface path with resistance appreciably lower than that of the material itself. It appears that this shielding effect is dependent upon the relationship between the size of the supporting rod and the inside diameter of the recess, which determines the width of the annular opening through which the evaporated or sputtered material must pass to reach the walls at the bottom of the recess, and the depth of the recess. As a typical example, and for explanatory purposes, it may be stated that a depth of recess in the order of five times the width of the annular opening represents a suitable relationship for certain tube structures such as illustrated. For other tube structures, involving a different relationship between the insulating element of the grid and the principal sources of evaporated or sputtered material, a different ratio of depth of recess to its annular width may be employed; and it should be understood that this invention is not limited to the particular ratio above stated, but is intended to embrace all shapes and dimensions of recesses which will afford the desired protective or shielding effect.

Resuming consideration of the particular structural organization illustrated, the lower ends of the three grid supporting rods **32** are welded to cross members **38** as shown in Figs. 1 and 6; and one of these members **38** is bent and extends through a seal in the stem **17** to form an external grid connection. The supporting rods **32** and their connections have sufficient rigidity to hold grid in the proper position vertically, in spite of some slight end play of these supporting rods **32** in the inner tubes **34** and these inner tubes within the outer tubes **36**, due to the mechanical clearances required for manufacture and assembly. The insulating tubes **34**, **36**, however, restrain lateral or sidewise movement of the grid, in spite of the distance between it and the point of anchorage of its supports in the stem **17**. This structure thus provides a rigid support directly to the heat shield and cathode assembly in such a way that the tube may be subjected to shock and vibration to a high degree without damaging the welded connections of the supporting elements, or disturbing the relationship between the grid and the other electrodes. In this connection, it can be appreciated that the anchorage of the grid supporting rods **32** to the cathode heat shield S obviates a vibratory motion of the grid that might otherwise occur due to the

long lever arm, so to speak, between the grid and its anchorage in the stem. Also, supporting and insulating the grid against lateral displacement in the manner characteristic of this invention, permits adequate grid support by the same element sealed in the stem to afford the external grid connection, and enables the crimped collar 16 on the stem 17, that would otherwise be used to advantage for supporting the grid, as disclosed in our prior Patent No. 1,989,132, January 29, 1935, to be utilized to provide a more rigid and substantial support for the more bulky cathode and heat shield assembly.

In the specific type of gas tube structure illustrated, a grid shield is preferably provided for the control grid. This grid shield (see Figs. 1 and 5) comprises an annular sheet metal piece 42, having a central discharge opening therein as indicated at 43, corresponding approximately with the diameter of the grid and having a deep down-turned peripheral flange. This grid shield 42 is connected to the cathode heat shield S by a plurality of supports 44 (three as shown) of a channel-shaped cross section, the legs of the channel being welded at the outer shield can 5, and the back of the section to the inside of the flange of the grid shield 42. This grid shield 42 is at cathode potential, and serves to reduce the effective anode to grid capacity, and also restrict movement of electrons under the influence of the electrostatic field of the anode to paths under the control of the grid.

Considering now the anode structure of this invention, tantalum has the advantage that it readily gives up occluded gases and has an affinity for gases other than the rare gases, such as xenon, preferably employed as a gas filling for grid control gas tubes. Tantalum, however, has the disadvantage that it is a relatively poor conductor of heat in the thickness preferably employed on account of its cost and ease of degassing. Also, the natural surface characteristic of tantalum renders it a relatively poor heat radiator. For these reasons, a tantalum anode for a tube of high current rating tends to become over-heated, particularly in localized areas where the discharge current may concentrate. Such overheating of the anode is objectionable, because among other things it provides a temperature at which the anode may be objectionably emissive, particularly if its surface has accumulated some active material, such as barium, sputtered from the cathode during the operation of the tube. Such electron emission from the anode interferes with the proper performance of the tube, such as by tending to reduce the inverse voltage rating and increase the likelihood of an arc-back in the case of a gas tube.

In order to reduce such localized overheating of a tantalum anode, it is proposed in accordance with this invention to provide supplemental elements attached to the anode, which have good heat conducting and radiating properties, and which act to conduct heat away from the greater part of the anode surface and dissipate such heat by radiation to the walls of the tube, and by conduction to the external leads. In other words, it is proposed to facilitate conduction and radiation of heat from a tantalum anode by attaching thereto members of some other metal which afford adequate radiating surface, and serve to equalize the temperature between different portions of the anode.

Another problem in the use of tantalum as an anode material is that when nickel is used for forming a welded support for the anode, it is found that the welded connection, although apparently mechanically strong, weakens and fails. This is apparently because an alloy of a relatively low melting point is formed in welding nickel to tantalum, so that the welded connection will not stand the high temperature which is required for adequate degassing, and which the anode may assume in operation. We have found, however, that a support of iron or steel may be welded readily to tantalum, and will afford a welded connection of adequate strength at the desired temperatures.

In view of these considerations, the tube structure of this invention involves attaching to the anode heat conducting and radiating members of iron or steel, or other alloy including iron, which may be termed a ferrous metal. In the specific structure illustrated, referring to Figs. 1 and 4, the anode A is a thin circular sheet of tantalum, which is formed with an upturned peripheral flange and with ribs or corrugations 46 extending radially from a central flat portion 47 toward its periphery. This flange and the ribs 46 are provided to give sufficient stiffness to the tantalum sheet and prevent it from bending or warping when heated during the degassing and exhaust procedure.

This tantalum anode A is supported by two heat dissipating members of sheet cold rolled low carbon steel, or an equivalent iron alloy, designated as whole B. Each of these members comprises flat heat radiating plates 50 disposed vertically and welded to a pair of rigid supporting rods 51, which are connected to rods sealed in a glass cap 52 attached to the end of the glass envelope E. These dissipating members B are formed with feet 53, which extend toward each other to cover substantially all of the central flat area 47 of the anode; and these feet 53 are spot welded to the anode at a large number of closely spaced points, as indicated in Fig. 4.

In order that the heat dissipating members B may conduct heat from the anode A to the best advantage, it would be desirable to provide intimate surface contact between the two metals throughout the entire area; but on account of the difficulty of obtaining a uniform and satisfactory union over a large surface between a thin sheet of tantalum and the heat dissipating members by any simple welding operation, it is proposed in accordance with this invention to spot weld the feet 53 of the heat dissipating members B to the sheet of tantalum of the anode A at a large number of closely spaced points. This spot welding operation is carried out by using a high welding current for a very short time to avoid heating the tantalum around the area of contact of the spot welding electrode, which would otherwise tend to oxidize the exposed tantalum and make it brittle. It can be appreciated that spot welding at such a large number of closely spaced points will afford suitable contact and union between the metals over a large area for adequate heat conduction from the tantalum anode to prevent its overheating.

It may be pointed out in this connection that, although tantalum and a ferrous metal have different coefficients of expansion, they may be heated to relatively high temperatures during the degassing procedure or in operation of the tube, when spot welded in this manner, without damage to the welds, apparently because the metals may stretch or compress between the welded spots without breaking the welds. In this connection,

the heat dissipating members B are preferably formed of thin sheet stock, with a thickness in the order of about one millimeter, in order to facilitate degassing these members; but the large areas involved afford the desired strength and heat conductivity.

It can be seen that this anode structure provides heat conduction from the central area of the tantalum anode A at a large number of points to the heat dissipating members B, where the heat is then radiated to the walls of the tube envelope E from the bodies of these members, acting as radiating surfaces or fins, and is partly dissipated by conduction through the supporting rods 51 to the external leads. These heat dissipating members B also act to conduct heat from one area to another of the anode, and avoid localized overheating of the anode.

A modified form of a heat dissipating anode support is shown in Figs. 9 and 10, in which the additional heat dissipating element is in the form of a cylindrical cup 57, which has its bottom spot welded at a number of closely spaced points to the central area 47 of the anode A. The two supporting rods 51 are welded to the walls of this cup 57; and this cup is preferably formed with longitudinal slits 58 extending for a substantial part of its length, so that the cup may expand and contract during the temperature changes in degassing operation, or during operation, without imposing stresses upon two supporting rods 51 that might otherwise damage the sealing support of these rods.

Another modification of the anode support is illustrated in Figs. 11 and 12, in which the cup-shaped heat dissipating element 57 of Fig. 9 is provided with an exterior flange 59 welded thereto and spot welded at a number of points to the anode, so as to cover a larger area of the anode surface.

After the tube structure shown and described has been assembled and mounted in the envelope E, the tube is subjected to a rigid schedule of degassing and exhausting, using the usual exhaust tube indicated at 60. This schedule includes heating the tube elements, supports and envelope by induction heating, by conduction current, and by baking, and preferbaly involving the steps disclosed in our prior Patent No. 2,044,350, dated June 16, 1938, so that all parts of the tube, including the envelope are free of occluded gases to a high degree. In the case of the gaseous discharge tube illustrated, the envelope is then filled with a suitable gas at the proper pressure, preferably in inert gas such as argon, krypton, xenon, or the like.

Various modifications, adaptations and additions may be made to the specific structures shown and described without departing from the invention.

What I claim is:

1. A grid control electron discharge tube comprising, a thermionic emissive cathode, a heat shield surrounding said cathode and having a discharge opening therein, a control grid adjacent said discharge opening, and means supporting and insulating said grid from said heat shield including a plurality of insulating elements of ceramic material attached to said heat shield, and a plurality of metallic elements attached to said control grid, said insulating and metallic elements cooperating to shield certain surfaces of the insulating elements from the accumulation of evaporated material, thereby preventing formation of a continuous film of evaporated material on the exposed surfaces of said insulating element to constitute a surface leakage path of reduced resistance from the control grid to said heat shield.

2. An electron discharge tube comprising, an envelope enclosing a thermionic emissive cathode and a heat shield for said cathode having a discharge opening therein, a grid adjacent said discharge opening for governing the electron current, a plurality of supporting rods for said grid sealed in said envelope near one end, and means for also supporting said supporting rods from said heat shield including insulating elements of steatite fixed to said heat shield, each of said insulating elements being shaped to have portions of its exposed surfaces shielded by the associated supporting rod from the accumulation of evaporated material.

3. A grid control electron discharge tube comprising, an envelope including a thermionic emissive cathode and a heat shield around said cathode having a discharge opening, a control electrode within said envelope opposite said discharge opening, a plurality of supporting rods for said control electrode sealed near one end in said envelope, and means for also supporting said rods from said heat shield including steatite sleeves attached to said heat shield, said sleeves each having recessed ends around said rods to prevent the formation of a surface leakage path by the accumulation of conductive material evaporated or sputtered inside the envelope.

4. A grid control gas discharge tube comprising an envelope; a thermionic emissive cathode, an anode, a heat shield and supporting elements within said envelope constituting sources of vaporized conductive material when heated during fabrication and in operation of the tube; a control electrode in said envelope; and means for supporting and insulating said control electrode from said heat shield including a rod passing through an insulated sleeve of steatite attached to said heat shield, said sleeve having at its ends recesses around said rod shaped to prevent the formation of a surface leakage path by the deposit of vaporized conductive material.

5. A structure for supporting and insulating an electrode inside the envelope of an electron discharge tube comprising, a sleeve of steatite fixed in position inside the envelope, and a supporting rod extending through said sleeve, said sleeve having at each end a recess around said rod shaped to shield portions of its surface from a deposit of evaporated or sputtered conductive material from sources in the envelope, and thereby prevent the formation of a surface leakage path by the accumulation of such conductive material.

6. A grid supporting structure for electron discharge tubes comprising, a plurality of supporting rods supported near one end to the tube envelope, a separate element in said envelope supported thereby, and means attaching said supporting rods to said separate element comprising sleeves of steatite surrounding said rods, said sleeves having at each end deep recesses around said rods shaped to prevent the formation of a surface leakage path by deposit of vaporized material from within said envelope.

7. An insulated supporting structure for an element of an electron discharge tube comprising, in combination with a fixed sleeve of steatite, of a metallic supporting rod passing through said sleeve, said sleeve having at each end an an-

nular recess around said rod having a depth in the order of five times its annular width.

8. A grid supporting structure for electron discharge tubes comprising, in combination with a control grid and a separately supported element in an envelope, a plurality of supporting rods attached to said grid, and snugly fitting inner and outer tubes of ceramic material surrounding each of said supporting rods for a portion of its length, said inner tube being shorter than the outer tube to provide a long recess at each end around the associated rod to prevent the formation of a surface leakage path by deposit of vaporized conductive material.

9. An insulating supporting structure for an electrode in the envelope of an electron discharge tube comprising, an insulating sleeve of steatite having deep recesses at its ends, a metallic rod extending through said recesses and passing through said sleeve, said rod after assembly being formed with shoulders engaging the bottoms of said sleeves to prevent its endwise movement in said sleeve.

10. An insulating support for electron discharge tube elements comprising, in combination with a supporting rod, of a tube of steatite around said rod for a portion of its length, said rod after assembly being formed with enlarged portions constituting shoulders engaging the ends of said tube to prevent endwise movement of the rod in said tube, another tube snugly fitting around the first tube and projecting beyond the ends thereof to form deep annular recesses around the portions of said rod extending beyond the inner tube.

11. An insulated support for electron discharge tube, comprising, in combination with a metallic supporting rod, of a sleeve of steatite around said rod for a portion of its length, means including an external groove in said sleeve fixing it in position in the tube envelope, said rod after assembly with said sleeve being formed with shoulders to prevent its endwise movement in the sleeve, said sleeve having annular recesses around said rod having a depth several times the annular width.

12. An electron discharge tube comprising, an envelope enclosing an anode of thin tantalum, and means for supporting said anode from one end of said envelope including a supporting element of a ferrous material welded to said tantalum.

13. An anode structure for electron discharge tubes comprising an anode of thin tantalum, and a plurality of supporting members of a ferrous metal welded to said anode at spaced points.

14. An anode structure for electron discharge tubes comprising, a planar anode of thin tantalum, and a supporting and heat dissipating element of an iron alloy welded to said tantalum at a large number of closely spaced points over a substantial area.

15. An anode structure for electron discharge tubes comprising, the combination with a thin planar tantalum anode, of two supports for said anode sealed in the tube envelope, and heat dissipating members welded to said supports and to said anode at a large number of closely spaced points.

16. An anode structure for electron discharge tubes comprising, a circular thin sheet of tantalum having a peripheral flange, and a thin flat supporting member of iron spot welded to an extensive surface of said disc at a plurality of closely spaced points.

17. In an anode structure for electron discharge tubes comprising, a planar anode of thin sheet tantalum, and heat dissipating members for supporting said anode, each of said members having an extensive radiating surface and being spot welded to said tantalum sheet over an extensive area at closely spaced points.

18. An anode structure for electron discharge tubes comprising, a planar anode of thin sheet tantalum, and a supporting and heat dissipating member of a thin sheet of iron, said member having a radiating surface and a separate attaching surface, said member having its attaching surface spot welded to said tantalum anode over an extensive area at a large number of closely spaced points.

19. An anode structure for electron discharge tubes comprising, a planar anode of thin tantalum having a peripheral flange and radial corrugations for stiffness, and a supporting and heat dissipating element for said anode including an iron cup spot welded to a central flat portion of said anode at a large number of closely spaced points.

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