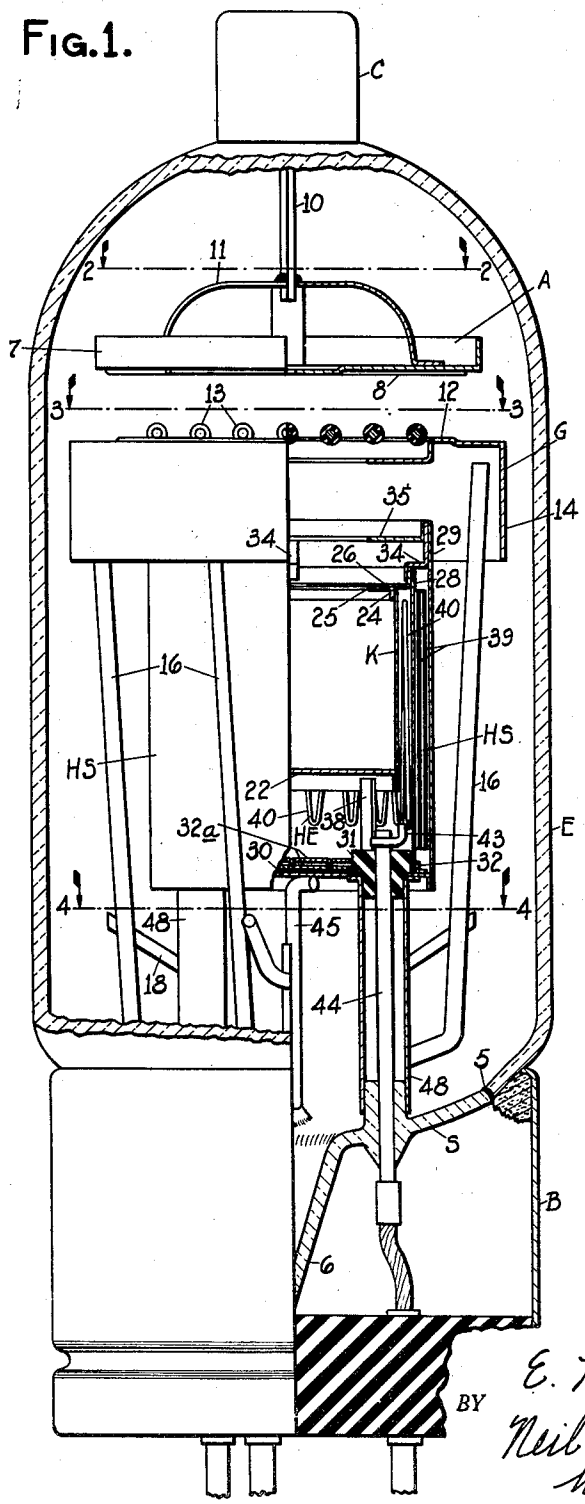
July 29, 1952 E. K. SMITH 2,605,432

INDIRECTLY HEATED CATHODE STRUCTURE

Filed Oct. 19, 1949 3 Sheets-Sheet 1

FIG. 1.



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INDIRECTLY HEATED CATHODE STRUCTURE

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FIG. 2.

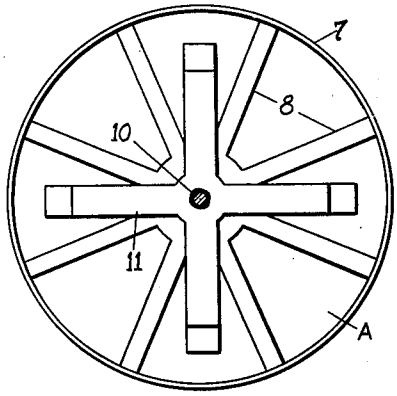


FIG. 3.

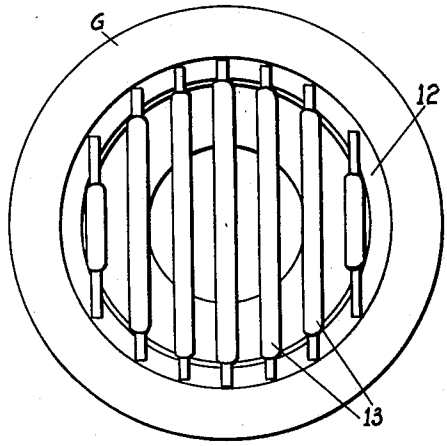


FIG. 4.

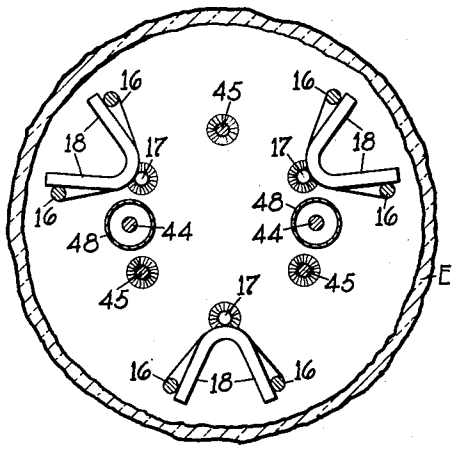
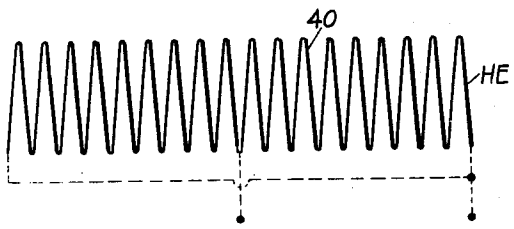


FIG. 5.



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INDIRECTLY HEATED CATHODE STRUCTURE

Filed Oct. 19, 1949 3 Sheets-Sheet 3

FIG. 6.

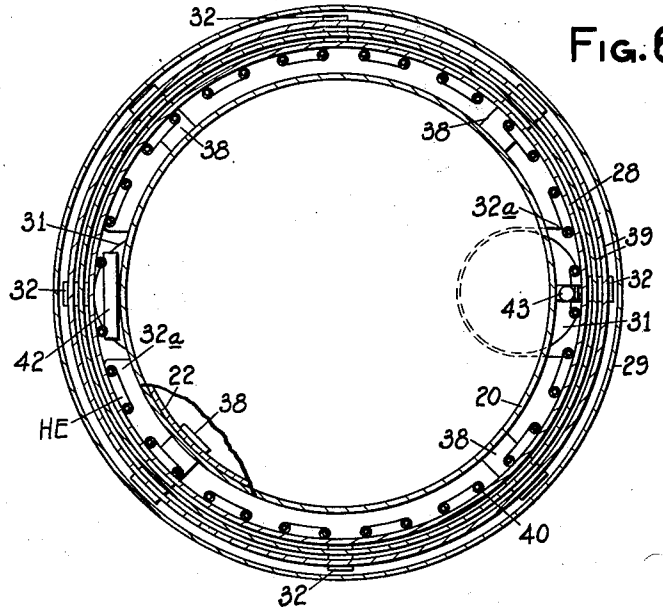
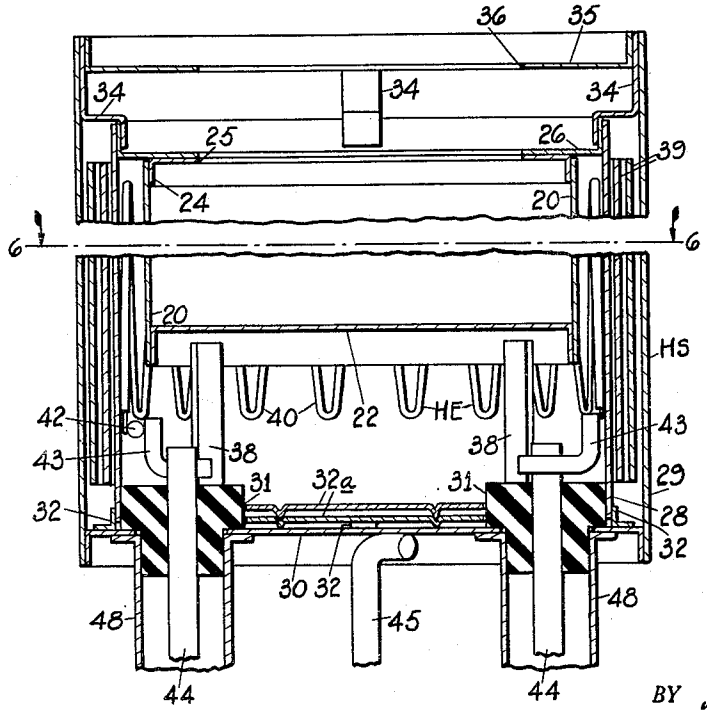


FIG. 7.



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UNITED STATES PATENT OFFICE

2,605,432

INDIRECTLY HEATED CATHODE STRUCTURE

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Application October 19, 1949, Serial No. 122,209

10 Claims. (Cl. 313—38)

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This invention relates to indirectly heated cathode structures for electron discharge tubes, and more particularly to cathode structures of the indirectly heated oxide coated type for gas tubes of the higher continuous current ratings.

In certain types of electron discharge tubes, such as gas tubes capable of conducting amperes of current, a relatively large emissive cathode surface is required; and such cathode is conveniently and ordinarily directly heated by comparatively large currents at a low heater voltage, in the order of three volts. In certain applications and uses of such tubes, however, as for example on airplanes, the power supply facilities available make it desirable to employ a higher voltage for heating the cathodes of the tubes, such as for example 14 volts. The use of such a heater voltage calls for indirect heating of the cathode.

It is desirable that the emissive surface of the cathode for a gas tube should be heated evenly and uniformly, otherwise there may be localized overheating and hot spots which adversely affect the useful life of the cathode. When a relatively large cathode emissive surface is to be indirectly heated, it is desirable to provide a heating element in such form as to radiate heat to a large proportion of the total cathode surface, so as to obtain the desired uniform heating. Also, the larger the ratio of the surface of the heating element to the surface of the cathode to be heated, the lower the temperature of the heating element has to be to obtain the desired cathode temperature; and it is desirable for long life of the heating elements and its insulation to keep its operating temperature as low as possible. Under such conditions, it is advantageous to employ a heating element in the form of a distributed winding with many closely spaced turns or loops, so as to provide the desired uniform heating by a heating element operating at a relatively low temperature. The various turns or loops of such a winding for a heating element should be held in position against movement or displacement by jar or vibration, otherwise the desired space relationship for uniform heating is disturbed, and also the heat resistant insulation on the heater wire is likely to be damaged by a rubbing contact resulting from such motion under the influence of vibration.

Further, it is desirable that the heating element should be closely spaced to the cathode, but not have direct contact with it. Among other things, the heating element for these

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tubes in many applications and uses is not electrically isolated from the cathode, and any deterioration or break-down of insulation where the heating element is in direct contact with the cathode may permit a voltage to be applied across a portion of the heating element sufficient to burn it out. Also, my experience indicates that, when the heater element touches the outer surface of a thin walled hollow cathode with oxide emissive coating on its interior, there is a tendency for the insulation of the heater to deteriorate, apparently due to some reaction between this insulating material and an element of the oxide coating, presumably barium, with which the thin core metal of the cathode is impregnated.

With these and other considerations in mind, the primary object of this invention is to provide a simple structure for indirectly heating a hollow cathode having an extensive emissive surface in such a way as to satisfy these requisites for a dependable and satisfactory life of the cathode and its heating element. A further object of the invention is to devise an indirectly heated cathode structure which is simple in design and may be easily and economically produced.

Generally speaking, and without attempting to define the nature and scope of the invention, it is proposed to obtain the desired indirect heating of a heat shielded oxide coated hollow cathode by providing as a heating element a preformed flat winding of closely spaced loops or turns of tungsten wire or the like, coated with aluminum oxide or equivalent heat insulating material, which is interposed between the cathode and its heat shield in such a way as to have all of its parts maintained by frictional engagement with the wall of the heat shield in a position close to but out of direct contact with the cathode.

Various other characteristic features and attributes of the cathode structure of this invention will be in part apparent, and in part pointed out as the description progresses.

Although the cathode structure of this invention may take various forms and be employed for various types of tubes, it is convenient in discussing the nature of the invention to refer to a typical tube including one specific embodiment of the cathode structure of this invention, as illustrated in the accompanying drawings. In these drawings, Fig. 1 is an elevation of the tube, partly in section; Figs. 2, 3 and 4 are transverse sections through the tube on the lines 2—2,

3—3 and 4—4 respectively in Fig. 1; Fig. 5 is a view of the heater winding prior to its assembly in the tube; Fig. 6 is an enlarged transverse section through the heat shielded cathode structure, taken on the line 6—6 in Fig. 7; and Fig. 7 is an enlarged view of the upper and lower parts of the heat shielded cathode.

The typical tube structure illustrated, including one specific form of an indirectly heated cathode embodying this invention, comprises in general an anode A, a control element or grid G, and a heat shielded indirectly heated cathode structure, all included in a glass envelope E. The grid G, cathode K and its heat shield HS and heating element HE are supported on a circular stem mount S whcih has its periphery fused to the envelope E, as indicated at 5, after these tube elements have been mounted and are to be assembled inside the envelope. This stem mount S is provided with a suitable exhaust tubulation indicated at 6; and the finished tube is provided with the usual pin base B cemented to the envelope E, all in accordance with conventional tube design.

In the particular tube illustrated, the anode A comprises a circular metal sheet, preferably tantalum, which has an upturned peripheral flange 7, and is provided with radial corrugations or ribs 8 (see Fig. 2), so that the relatively thin tantalum sheet is not unduly warped or distorted when heated. This anode A is supported by a rod 10, sealed in the upper end of the envelope E in the usual manner and provided with a terminal cap C, of well known construction. The lower end of this anode supporting rod 10 is welded to the center of the cruciform member 11, which has its arms bent down and terminating in flanges welded to the anode.

The grid G in the typical tube structure shown is in the form of an inverted cup of sheet nickel having a central discharge opening surrounded by a circular raised rib 12 to which the ends of the grid bars 13 are welded, the vertical wall of the cup forming a skirt 14 for the grid to enclose and shield the region between the heat shielded cathode and the discharge opening covered by the grid bars. The grid bars 13 are preferably of tungsten formed with a coating to inhibit electron emission in the manner disclosed in the prior patent to D. V. Edwards, No. 2,012,339, August 27, 1935.

In the particular structure illustrated, the grid G is supported by three rods 16 each bent in the form of a hairpin, which have their upper separated ends welded to the inside of the skirt 14 of the grid G, as best shown in Fig. 1. The lower bent ends of these hairpin shaped rods 16 are welded to three grid supporting posts (see Fig. 4), which are anchored in the circular stem mount S, one of these posts 17 extending through a seal in this stem mount to the outside of the envelope to constitute a lead-in connection for the grid G. The connection between each of the hairpin shaped rods 16 and its corresponding supporting post 17 is reinforced by a curved brace 18 welded near its middle to the post 17 and at its ends to the rod 16, as best shown in Fig. 4.

The cathode structure, which represents the subject matter of this invention, comprises in general a hollow thin wall cylindrical cathode K having an oxide coating on its inner surface, a heating element HE around the outside of this cathode, and multiple wall cylindrical heat shield HS surrounding and enclosing the heating element and cathode, except for a discharge opening opposite the grid G.

In the particular structure illustrated, the cathode K is formed of a cylinder 20 of nickel to which is welded near its lower edge the peripheral flange of a bottom piece 22. The upper end of the cathode cylinder 20 is partially closed by a flanged top member 24 welded thereto and having the usual circular discharge opening 25 therein. To this top member 24 is welded an additional or secondary top member 26 provided with a similar discharge opening, but of larger outside diameter and having a peripheral flange for attachment to the inner can of the heat shield HS. The inside surface of the cathode cylinder 20 and the bottom piece 22 of the hollow cathode thus formed are coated with an emmisive coating, preferably of the barium nickelate type prepared in accordance with the prior patent to D. V. Edwards et al., No. 2,081,864, May 25, 1937.

The heat shield HS comprises inner and outer cylindrical cans 28 and 29 of thin nickel which surround the cathode K, except for a discharge opening, and which provide a heat shielded enclosed space around the cathode for the heating element HE. In the particular construction of the heat shield HS shown, the outer heat shield can 29 comprises a cylinder to which is welded the peripheral flange of a bottom 30 having two diametrically opposite openings for receiving insulator bushings 31 of steatite or like heat resistant insulating material. In order to reduce heat radiation from the bottom piece 22 of the cathode through the bottom of the heat shielding structure, a multiple wall bottom for the heat shield HS is preferably used. In the arrangement shown, a plurality of thin nickel sheets 32a, two as shown, which are preferably pimpled or ridged to maintain a separation between their surfaces, are spot welded together at a few points and to the bottom 30 of the outer heat shield can 29, said sheets 32a being cut away to fit around the insulator bushings 31.

The inner heat shield can 28 comprises a cylinder which is attached at its lower end by small brackets 32 to the bottom 30 of the outer heat shield can 29. Three such brackets 32 are shown in Fig. 7, but other brackets not shown are used to attach the lower edge of the inner heat shield can 29 to the bottom 30 at a sufficient number of points around its periphery to prevent collapse or distortion of its relatively thin cylindrical wall, which acts as presently described to hold the heater element in the desired position. If desired, the dimensions of the insulator bushings 31 may be chosen so that they will engage the inner heat shield can 28; and in that case the brackets 32 shown at such points may be omitted.

The upper edge of the inner heat shield can 28 is welded to the flange of the secondary top member 26 of the cathode K. Four bent brackets 34, also welded to the flange of the secondary top member 26 of the cathode, have their upper ends, together with the peripheral flange of the heat shield cover 35, welded to the upper end of the outer heat shield can, said heat shield cover 35 having a discharge opening indicated at 36 of a size comparable with the discharge opening 25 for the cathode. Four bent strips 38, constituting supporting feet for the cathode, are welded to the inside of the flange of the bottom piece 22 and have flanges at their lower ends welded to the bottom 30 of the heat shield HS. A wrapping of two or more thicknesses of a sheet of pimpled or ribbed nickel is interposed between the inner and

outer heat shield cans, as indicated at 39, to increase the heat shielding. The brackets 34 and strips 38 are preferably made of a width and thickness to keep down conduction of heat from the cathode to the outer heat shield can 29, while affording the desired rigidity to the assembly.

The heating element HE of this invention comprises essentially a flat band or ribbon type winding 40 of closely spaced loops or turns of wire coated with a heat resistant insulating material. The preferred structure consists of tungsten wire bent in a zig-zag fashion as shown in Fig. 5. After the wire has been shaped, it is heated in a hydrogen atmosphere to cause the wire to assume a substantially permanent set. This preformed winding is then dipped or sprayed with aluminum oxide in a suitable binder for the desired thickness of insulation, and is baked to form a coating or covering for the tungsten wire which has the desired heat resistant and electrical insulating qualities.

In accordance with this invention, this preformed heater winding 40 is made slightly longer, in the order of 10 to 15 per cent, than the inner circumference of the inner heat shield can 28; and when this winding is positioned inside this heat shield can, the inherent resiliency of this winding causes it to expand rather tightly against the inner surface of the heat shield can, thereby providing a frictional engagement with its inner wall sufficient to hold all of the parts of the winding in the proper space relation against movement under the influence of jar and vibration to which the tube may be subjected. This construction permits the loops or bends of the heater winding 40 to be spaced as closely as needed for the desired uniform heating of the cathode, without involving complex or expensive mechanical means for maintaining the individual loops in place. It will be evident that the frictional engagement characteristic of this invention enables any appropriate dimension and space relationship of the heater winding to be employed, and still have all of the parts of the winding maintained in position after assembly. Further, the heater winding 40 when in position may be closely spaced to the cylindrical wall of the cathode, but without direct contact with it. This heater winding 40 is preferably somewhat wider than the depth of the cathode K, so that the ends of the loops of this heater winding extend below the bottom piece 22 of the cathode, as shown in Fig. 1, thereby enabling the heater winding 40 to radiate heat to this bottom piece 22 of the cathode and heat it to a temperature comparable with the side walls of the cathode.

For the particular tube illustrated, which is designed for operation of the heating element with fourteen volts, it is expedient to use a size and length of wire for the heater winding such that the heater voltage is applied to halves of the heater winding in multiple. In other words, the two ends of the pre-formed heater winding 40 are connected together for one terminal of the heating circuit, and a tap is provided at a midpoint of the winding for the other terminal of the heating circuit, as indicated by dotted lines in Fig. 5. The bared ends of the heater winding are welded to a short connector 42 (see Figs. 6 and 7); and this connector 42 and the bared mid-tap of the heater winding 40 are welded to angular lugs 43, as best shown in Fig. 7; and these lugs 43 are welded to the upper ends of rods 44 extending through the insulator bushings 31. These rods 44 extend through seals in the stem mount S to the exterior of the envelope, as shown in Fig. 1 for one of these rods, so as to constitute lead-in connections for the external heating circuit. It will be noted that the insulator bushings 31 are formed with a shoulder to limit their downward movement, and have their upward movement limited by the lugs 43 on the rods 44.

The heat shield HS, to which the cathode K is attached as above described, is supported in the envelope by three rods 45 which have their upper bent ends welded to the bottom 30 of the outer heat shield can 29, and which have their lower ends anchored to the stem mount S. One of these rods 45 extends through a seal to the outside of the envelope to constitute the cathode connection.

The seal or anchorage in the stem mount S for the rods 44 supplying heating current to the heater element HE are preferably in the form of an enlarged bead, as best shown in Fig. 1; and a shielding sleeve or tube 48 fits over this bead at its lower end, and fits at its upper end over the associated insulator bushing 31, with a flange welded to the bottom 30 of the heat shield HS. This sleeve 48, which may be made of a suitable metal, such as nickel, or an appropriate insulating material, such as glass or steatite, shields the rods 44 connected to the heater element HE throughout their length below the heat shield HS from the gas filling in the envelope for reasons presently explained.

In an indirectly heated cathode for gas tubes, where the heater voltage is higher than the ionizing voltage for the gas filling at its operating pressure over a moderate mean free path distance, it is desirable that all parts of the heating circuit inside the tube envelope should be isolated from ionization of the gas filling. Even though such portions of the heating circuit may not assume temperatures high enough for primary electron emission sufficient to initiate cumulative ionization and an arc dicharge, if these parts are exposed to the gas filling in its ionized condition otherwise initiated, the difference in potential between such parts may be sufficient to maintain a discharge, with the electrons produced by ionic bombardment. Such arc discharge between parts of the heater circuit, even though it may be extinguished when the alternating voltage commonly used for the heating circuit goes through zero, has the general effect of a low resistance short circuit; and if this arc discharge does not overheat and burn out the exposed parts, it tends to interfere with the proper operation of the heater element, and overloads the heating transformer.

For these reasons it is desirable to avoid an arc discharge between exposed parts of the heating circuit within the tube envelope; and since it is difficult, if not impracticable, to provide adequate insulation for the electrical connections to the heater windings, including the bared parts of the heater winding 40 attached to the lugs 43, and the ends of the rods 44 above the insulator bushings 31, all of these exposed portions of the heater element and its circuit connections are enclosed in a space isolated from the ionized gas filling. It will be noted that the upper end of the space around the cathode K above the heater element HE is closed by the secondary top 26 of the cathode, and the region below the cathode is enclosed by the bottom 30 of the outer heat shield can 29, together with the insulator bushings 31 and the inner heat shield can 28. Similarly, for the same reason, the portions of the rods 44 included in the heating circuit and

extending between insulator bushings 31 and the stem mount S are shielded by the tubes 48 from the ionized gas filling. In this connection, it should be understood that the desired isolation does not require gastight connections. It is sufficient if the gap or space opening to the gas filling is sufficiently narrow and deep relative to the mean free path of the gas filling that a sufficient number of gas ions may not move through this opening without being deionized by surface recombination into a region around exposed electrical connections of the heater element and cause an arc discharge under the influence of the potentials involved and the effect of positive space charge. Generally speaking, ordinary spot welding between the metal surfaces, such as the flange of the secondary top member 26 and the inner heat shield can 28, will afford the desired isolation effect, provided of course these surfaces are welded together at intervals close enough to avoid wide gaps by distortion of the relatively thin metal. In short, the desired isolation of the heater element and its circuit connections from the ionized gas filling of the tube may be obtained by providing close surface separations that may be readily attained by ordinary fabrication and assembly procedures, without attempting to make a gas tight joint.

In mounting and assembling the heat shielded cathode structure above described, so as to get the heater winding 40 in position and properly electrically connected within the enclosed space between the cathode and heat shield without damaging the insulation on the heater winding, it is convenient to assemble the bottom 30 of the heat shield HS, together with the shielding tubes 48 welded thereto, on the rods 44 of the stem mount S, slipping the lower ends of these tubes 48 over the enlarged beads on the stem mount around the rods 44, and welding this bottom 30 to its supporting rods 45. The lugs 43 for the electrical connection to the heater winding 40 may then be welded to the rods 44 with the insulator bushings 31 in place. The cathode, coated and fully assembled except for the secondary top member 26, may then be attached in position on the bottom 30 of the heat shield by welding the flanged ends of its supporting strips 38 to said bottom 30. The pre-formed heater winding 40 of Fig. 5, with its ends and midtap connection bared of insulation, is bent into a circle to slip over the cathode. After placing the heater winding 40 in this shape around the cathode and welding the electrical connections between the heater winding and the lugs 43, the inner heat shield can 28 is slid into place around the heater winding, which may then expand by its inherent resiliency into firm contact and frictional engagement with the inner wall of this heat shield can 28. The secondary top member 26 may then be welded to the top member 24 of the cathode, and the flange of this secondary top member 26, together with the ends of the brackets 34, are welded to the upper end of the inner heat shield can 28, whereupon the heat insulating sheet 39, the outer heat shield can 29, and the heat shield cover 35 may be applied to complete the assembly. The significant part of this procedure for mounting and assembling the cathode structure has to do with electrically connecting and positioning the heater winding 40 inside the inner heat shield can 28 in frictional engagement with its inside wall and out of contact with the cathode.

From the foregoing it can be seen that the indirectly heated cathode structure of this invention satisfies the various requisites described for obtaining uniform and consistent heating of relatively large emissive surfaces at a relatively low heater operating temperature, in a simple and effective manner, and in a way to give dependable performance and acceptable life for the heater element, largely free from deterioration of insulation, burn outs, and the like.

It should be understood that the specific indirectly heated cathode structure illustrated and described, and in particular the particular type of tube including such cathode structure, merely represents a typical embodiment of the invention; and various modifications, adaptations and additions may be made in the arrangement and construction of the parts shown and described without departing from the invention.

What I claim is:

1. An indirectly heated cathode structure for electron discharge tubes comprising, a hollow oxide coated cathode of cylindrical form, a heat shield around said cathode closely spaced thereto, and a heating element in the space between said cathode and heat shield, said heating element comprising closely spaced turns of heat resistant insulated wire preformed into a winding of some resiliency, said heating element when in place tending to expand against the inner wall of said heat shield, whereby the turns of said heating element are individually maintained against movement under jar and vibration largely out of contact with said cathode, by frictional engagement with said heat shield.

2. An indirectly heated cathode structure according to claim 1 in which the heating element comprises a band winding of zig-zag turns approximately ten per cent longer than the circumference of the inner wall of the heat shield.

3. An indirectly heated cathode structure according to claim 2, in which the turns of the band winding extend transversely thereof and provide substantial resiliency lengthwise of the band.

4. An indirectly heated cathode structure for electron discharge tubes comprising, a hollow cylindrical cathode of thin core metal having an oxide coating on its interior surface, a multiple wall heat shield having an inner cylindrical wall closely spaced to said cathode, and a heating element in the space between said heat shield and cathode consisting of a wire of a high melting temperature preformed into a band of closely spaced zig-zag turns and coated with a heat resistant insulating material, said heating element being of a width comparable with the length of said cathode and of a length slightly longer than the circumference of the inner wall of said heat shield, said heating element being contracted when assembled inside said heat shield and expanding into intimate frictional engagement with its inner wall to maintain the wire turns individually in position against jar and vibration.

5. An indirectly heated cathode structure comprising, a hollow cylindrical cathode of thin nickel coated on its interior with barium nickelate, a multiple wall heat shield surrounding said cathode except for a discharge opening and having an inner cylindrical wall closely spaced to the side wall of said cathode, and a heating element of closely spaced zig-zag turns of tungsten wire coated with aluminum oxide, said heating element extending around the side wall of said cathode with its turns lengthwise of the cathode and tending to expand against the inner wall of said heat shield, whereby said heating element has its turns individually maintained in position close to but

out of contact with the surface of said cathode by frictional engagement with said inner wall of the heat shield.

6. An indirectly heated cathode structure for gas tubes comprising, a hollow cylindrical cathode of thin core metal having an oxide coating on its inner side wall and bottom, a multiple wall heat shield inclosing said cathode and having an inner cylindrical wall closely spaced to the side wall of said cathode, a heater winding inside said heat shield in the space between its inner wall and said cathode, said heater winding having its individual turns held in position by frictional engagement with the inner wall of said heat shield, and a top member having a discharge opening therein and attached to the open end of said cathode and to said heat shield with closely spaced surfaces, whereby the space for said heating winding adjacent the open end of the cathode is isolated from ionization of the gas filling of the tube.

7. An electron discharge tube comprising a gas filled envelope, an indirectly heated cathode structure enclosed in said envelope, said cathode structure comprising a hollow cathode, a heat shield wholly enclosing said cathode except for a discharge opening, said heat shield including an inner wall closely spaced to the side wall of said cathode, a heater winding of insulated wire around said cathode in the space between it and the inner wall of said heat shield, leads of substantial rigidity for supplying heating current to said heater winding extending through and insulated from said heat shield and through seals in said tube envelope, said heater winding having bared portion welded to said leads inside said heat shield, said heater winding being maintained in position against movement by jar or vibration largely by frictional engagement with the inner wall of said heat shield and independently of the electrical connections to said leads, and shielding means around said leads throughout their lengths between the heat shield and the seals in the envelope for isolating these portions of said leads from ionization of the gas filling.

8. An electron discharge tube comprising a gas filled envelope, an indirectly heated cathode structure enclosed in said envelope, said cathode structure comprising a hollow cylindrical cathode, a heat shield surrounding said cathode except for a discharge opening and forming a narrow enclosed space around the side wall of said cathode, a heater winding in said enclosed space maintained in position close to but out of contact with the side wall of said cathode largely by frictional engagement with said heating shield, leads for supplying heating current to said heater winding extending through openings in said heat shield and through seals in said envelope, electrical connections between said heater winding and said leads inside said heat shield, bushings of heat resistant insulating material around said leads and filling the openings in said heat shield, and a shielding sleeve around each lead throughout its length between said heat shield and the tube envelope for isolating these portions of said leads from ionization of the gas filling.

9. An indirectly heated cathode structure for gas tubes comprising, a cylindrical hollow cathode, a multiple wall heat shield surrounding said cathode except for a discharge opening and having an inner wall closely spaced to the side wall of said cathode, a preformed heater winding of closely spaced turns of insulated wire approximately one-tenth longer than the circumference of said inner wall of the heat shield, said heater winding being contracted when assembled in the space between said inner wall of the heat shield and the cathode and expanding into frictional engagement with said inner wall in a position close to but largely out of contact with the side wall of the cathode, a gas filled envelope enclosing said heat shield and cathode and heater winding, heating circuit connections including rods extending through and insulated from said heat shield and also extending through seals in said envelope, said heater winding having bared portions electrically connected with said rods, the parts of the heating circuit connections inside said heat shield being isolated from ionization of the gas filling by the closely spaced surfaces of the parts of the heat shield assembly, and shielding means around all of the heating circuit connections outside of the heat shield having close surface contact with said heat shield and the tube envelope for isolating these parts of the heating circuit connections from ionization of the gas filling.

10. A gas tube having a hot cathode indirectly heated by a heating element operating at a voltage higher than the ionizing voltage for the gas filling of the tube and comprising, a cylindrical cathode oxide coated on its inner surface, a heat shield formed of a plurality of spaced sheet metal walls and surrounding said cathode except for a discharge opening, a heater winding in the space between said cathode and the inner wall of said heat shield, a pair of tubular insulators extending through holes in the bottom of said heat shield, a pair of leads connected to the terminals of the heater winding inside the heat shield and extending through said tubular insulators and seals in the tube envelope, each of said seals for said leads including an inwardly projecting boss, and a pair of shielding sleeves one around each lead extending from the heat shield to the surface of the tube envelope for isolating said leads from ionization of the gas filling, each shielding sleeve comprising a tube of thin metal having one end attached to the bottom of the heat shield around the associated insulator and the other end fitting around the boss of the seal for the associated lead, said metal shielding sleeves permitting movement of the heat shield relative to the tube envelope under changes in temperature without damage to the sleeves or the seals for said leads.

EARLE K. SMITH.

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