Sept. 1, 1953 W. W. WATROUS, JR 2,650,997

HEAT SHIELDED CATHODE

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FIG. 1

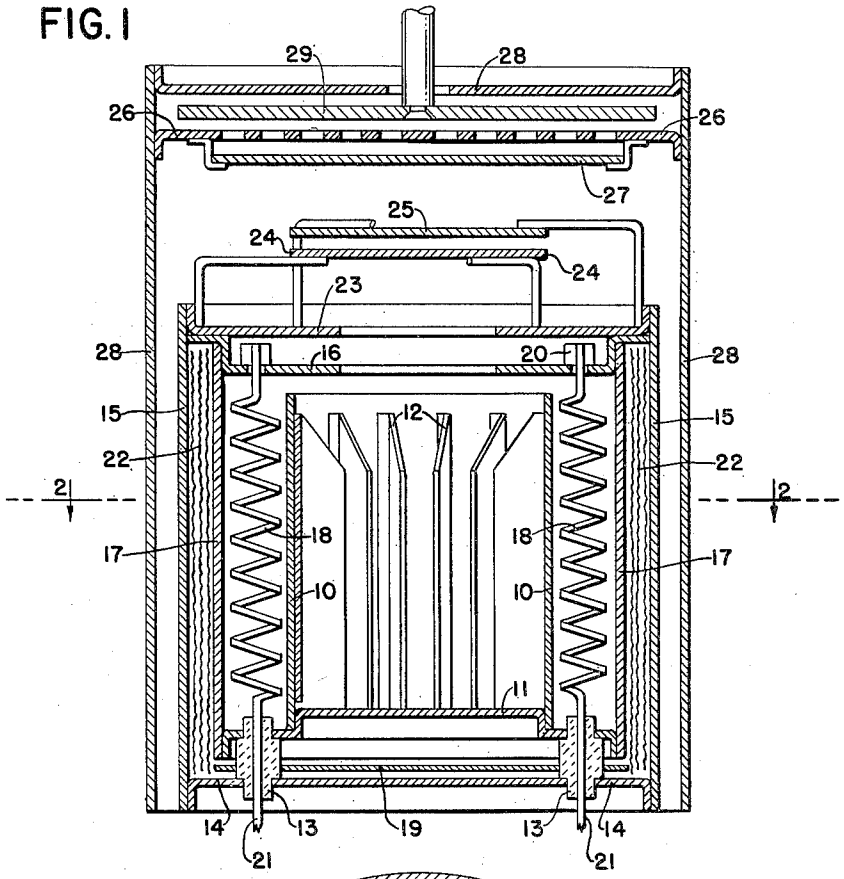
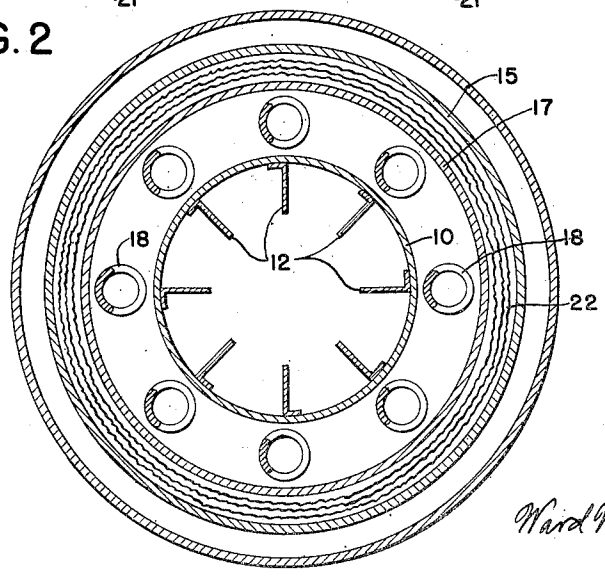


FIG. 2



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FIG. 3

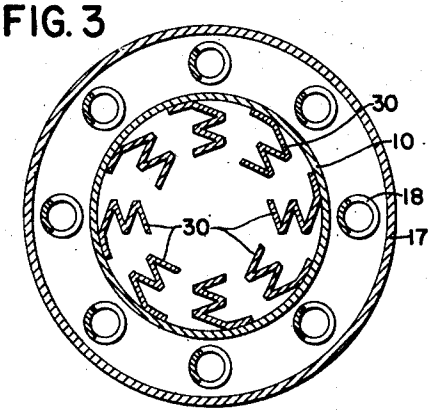


FIG. 4

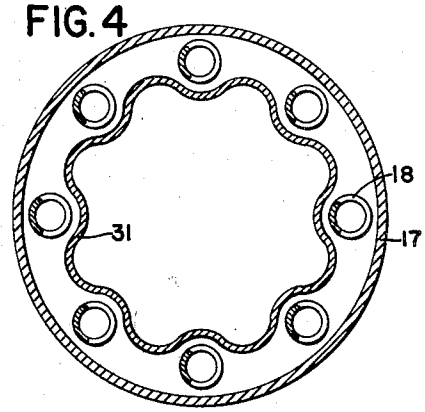


FIG. 6

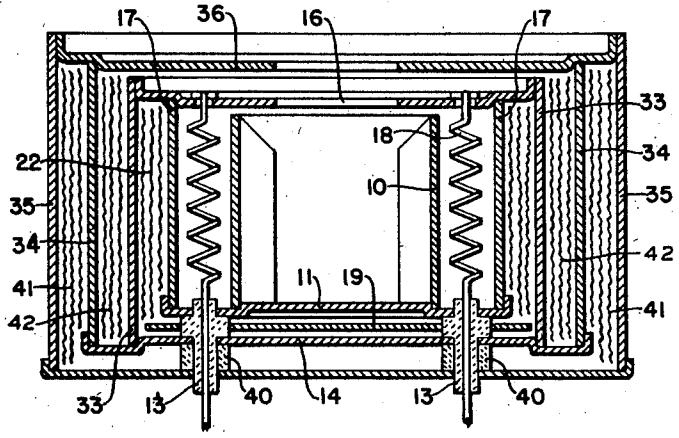
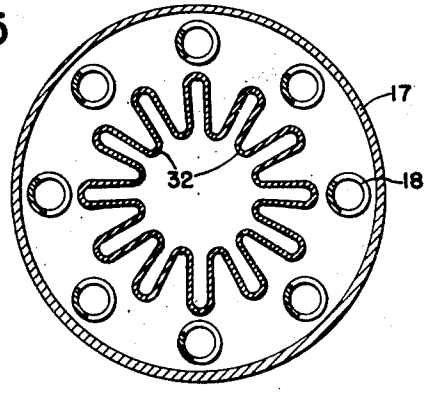


FIG. 5



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HEAT SHIELDED CATHODE

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4 Claims. (Cl. 313—38)

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This invention relates to heat shielded cathodes for electron discharge tubes, and has particular reference to cathodes which supply electrons for gas discharge tubes which are capable of passing large currents.

Many forms of indirectly heated cathodes have been used for electronic tubes. The most general type has an insulated heater unit in the center of a small metal tube with an emissive coating on the outside of the tube. This is a satisfactory type for small tubes which use currents of less than one hundred milliamperes. For larger currents vanes have been welded to the central tube to increase the emissive area of the cathode. A serious difficulty with large cathodes using considerable input power has been the loss of heat from the cathode to the heat shields, the other electrodes, and to the walls of the envelope.

One of the objects of this invention is to provide an improved shielded cathode structure which avoids one or more of the disadvantages and limitations of prior art arrangements.

Another object of the invention is to reduce the loss of heat from the cathode by metallic conduction through the heat shields and supports.

Another object of the invention is to increase the availability of the cathode emitting surfaces so that electrons may be readily emitted and ion formation, necessary to reduce space charge in the cathode region, may be rapidly effected.

Another object of the invention is to provide a cathode structure which will be efficient in producing electrons in which loss of heat by gas convection is minimized.

Still another object of the invention is to reduce the radiated heat from a heated cathode in order to increase the heating efficiency.

The invention comprises a heat shielded cathode for supplying electrons for high vacuum tubes or gas filled discharge devices and includes a hollow cylindrical conducting electrode which forms an enclosure. A plurality of heater elements are mounted adjacent to the outside surface of the hollow electrode for heating the electrode and causing electrons to be emitted from an electron emissive surface on the inside of the electrode. A reflecting cylinder is positioned around the heater elements for reflecting the radiated heat from the heater elements.

One feature of the invention comprises a plurality of fins mounted on the inside of the hollow electrode for increasing the area of the conductor and thereby decreasing the cathode current density and increasing the life of the tube.

Another feature of the invention includes a

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cathode structure which provides a relatively closed space for the heater elements, thereby decreasing the gas density in the space surrounding the heaters and greatly reducing heat loss by gas conduction.

Another feature of the invention comprises a second or outer cylinder mounted so as to surround the first or inner shield cylinder. The outer shield cylinder reflects the heat radiated from the inner cylinder.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

Fig. 1 is a cross sectional view of the heat shielded cathode shown in conjunction with an anode and a control electrode.

Fig. 2 is a cross sectional view of the cathode taken along line 2—2 of Fig. 1.

Fig. 3 is a sectional view of an alternate form of the cathode using corrugated fins inside the cathode enclosure.

Fig. 4 is another alternate form of the device in which the hollow cylindrical conductor is formed with corrugations to match the heater elements.

Fig. 5 is similar to Fig. 4 except the corrugations are more pronounced and do not conform to the heater element shape.

Fig. 6 is a cross sectional view similar to Fig. 1 but showing four shield cylinders instead of two.

Referring now to Figs. 1 and 2, a hollow electrode 10 is formed in a hollow cylindrical shape, made of conducting material, and closed at the lower end by a wall 11. On the inside of the electrode 10 a number of fins 12 are secured to increase the electrode area. The inside surface of the electrode and both sides of the fins are covered with electron emissive material such as the usual barium-strontium oxide film.

The lower wall 11 is part of a larger disk which extends beyond the cylindrical electrode 10 and is supported by twelve ceramic insulator blocks 13. The insulator blocks are supported by a base disk 14 which acts as a support for the entire cathode unit. An outer shield conductor 15, cylindrical in shape, is joined to the base plate 14 by means of a welded joint to a turned over portion on the base and the outer conductor 15 supports an upper plate 16 in a similar manner.

An inner shield conductor 17 is held between the upper wall plate 16 and the lower wall plate 11 and forms, with cylindrical electrode 10, an annular space in which a number of heater ele-

ments 18 are secured. The upper ends of the heater elements are welded to support angles 20 which in turn are welded to the upper plate 16. The lower ends of the heater elements are threaded through holes in the insulator blocks 13 and are joined to lead-in conductors 21 below the base plate 14.

The space between the inner shield conductor 17 and the outer shield conductor 15 is filled with loose fitting nickel sheets 22, each having a bright reflecting surface. These sheets are for the purpose of reflecting the radiant heat given off by the first or inner conductor 17 and thus blocking the heat flow from the cathode.

With the exception of the insulator blocks 13 and the heater elements 18, all the components consist of conductive metallic material such as nickel, iron, or molybdenum, chosen because of their ability to withstand elevated temperatures and because they rapidly evolve occluded gas during the exhaust process. These materials also conduct heat readily and for this reason the design includes a structure which presents a maximum path length for the conductive dissipation of heat. Thus, the heat loss from the hollow cathode 10 is considerably reduced, since the heat flow is by metallic conduction through a long path which includes the outer part of disk 11, the reflecting cylinder 17, the outer part of upper disk 16, and finally the reflecting cylinder 15.

The upper plate 16 contains a central hole through which electrons may be drawn when the proper electric field has been established. Above plate 16 is an additional heat shield plate 23 with a corresponding hole. Plate 16 is employed to shield the anode and control electrode from the radiant heat which is emitted by the heaters attached to bracket 20 and to minimize heat loss from the cathode itself. Above the hole in plate 23 are two baffle plates 24 and 25 which act as additional barriers to the radiant heat from the enclosure inside the cylindrical electrode 10 and to minimize the quantity of emissive coating vaporized from the cathode surface.

The control electrode 26 and its baffle plate 27 are well known structures which have been described in prior publications. Also, the shielded anode 29 surrounded by shield electrode 28 conforms to well known design. The extension of the shield electrode 28 to surround the anode 29 is a structure used to more completely control the flow of current between the anode and cathode.

When the discharge device is in operation, the heater elements 18 heat the cathode 10 to a temperature where electrons are emitted. A dense electron cloud is formed in the enclosure inside electrode 10 and when a high electric field is applied between anode and cathode the electrons are drawn to the anode 29 to effect a high anode current. During the operation of the tube the reflecting cylinder 15 remains at a relatively low temperature, minimizing loss of heat to the glass envelope by convection.

In the preferred design the heater elements are connected in pairs of two elements in series with other combinations of twos in parallel. This reduces the effect known as "jitter" in pulse modulation.

Fig. 3 is a partial illustration of a cathode similar to the cathode shown in Figs. 1 and 2 except that corrugated fins 30 are used to increase the electron emitting surface. The operation is the same as described above.

Fig. 4 illustrates an alternate method of forming the hollow cathode electrode. Instead of a cylindrical enclosure, side walls 31 are formed with corrugations to match the heater elements 18. The corrugations are formed so that a major portion of the conductor surface is equidistant from the heater surface and for this reason is more evenly heated. The result is more efficient emission and longer life.

The alternate design shown in Fig. 5 is another method of increasing the area of the emitting surface. Here a cathode conductor 32 is formed with corrugations which are deep and numerous and do not correspond to the heater elements.

The design shown in Fig. 6 is an extension of the heat reflector array shown in Fig. 1. An inner reflector 17 is used as described above to reflect the radiated heat from the heater elements 18. Three other reflectors 33, 34, and 35 are placed in concentric alignment to reflect back whatever radiated heat may be filtered through the inside reflectors. The mounting of the reflectors is designed to furnish a long path for the heat which tends to escape due to conductivity through the metal. The upper edges of reflectors 17 and 33 are secured and held in position by the outer portion of disk 16. The lower edges of reflectors 33 and 34 are secured by disk 14. The upper edges of reflectors 34 and 35 are secured by apertured disk 36. Finally the lower edge of reflector 35 is secured by base plate 37. To provide adequate spacing between plates 14 and 37 insulating spacers 40 are used in conjunction with insulators 13. The annular spaces between reflectors are filled as described above with radiant heat reflecting foil assemblies 22, 40, and 41.

Heat losses from the cathode enclosure and heaters 18 which travel by metallic conduction must proceed vertically in reflector 17, thence across part of disk 16 to reflector 33, down to disk 14, thence in like manner to reflector 34, disk 36, and finally reflector 35 and base plate 37.

From the above description it will be evident that the invention provides a cathode structure which is efficient in operation, provides a large cloud of electrons which can be easily withdrawn from the cathode enclosure and transfers a minimum amount of heat to the gaseous filling and the glass envelope.

While there have been described and illustrated specific embodiments of the invention, it will be obvious that various changes and modifications may be made therein without departing from the field of the invention which should be limited only by the scope of the appended claims.

I claim:

1. A heat shielded cathode for gaseous discharge devices comprising, a hollow cylindrical electrode mounted on a first disk which closes one end, a plurality of heater elements adjacent to the outside surface of the hollow electrode for heating the electrode to cause electrons to be emitted from the inner surface thereof, an inner reflecting cylinder having its lower edge coupled to the outside periphery of the first disk, said inner cylinder positioned adjacent to and surrounding the heater elements, a second disk mounted on the upper edge of the inner cylinder, and an outer reflecting cylinder having its upper edge secured to the periphery of the second disk, thereby providing a long metallic path for the conduction of heat from the hollow cylindrical electrode.

2. A heat shielded cathode for gaseous discharge devices comprising, a hollow cylindrical

electrode mounted on a first disk which closes one end, a plurality of heater elements adjacent to the outside surface of the hollow electrode for heating the electrode to cause electrons to be emitted from the inner surface thereof, an inner reflecting cylinder having its lower edge coupled to the outside periphery of the first disk, said inner cylinder positioned adjacent to and surrounding the heater elements, a second disk mounted on the upper edge of the inner cylinder, and an outer reflecting cylinder having its upper edge secured to the periphery of the second disk and its lower edge secured to a base disk, thereby providing a long metallic path for the conduction of heat from the hollow cylindrical electrode.

3. A heat shielded cathode for gaseous discharge devices comprising, a hollow cylindrical electrode mounted on a first disk which closes one end, a plurality of heater elements adjacent to the outside surface of the hollow electrode for heating the electrode to cause electrons to be emitted from the inner surface thereof, an inner reflecting cylinder coupled mechanically and thermally to the first disk, said inner cylinder positioned adjacent to and surrounding the heater elements, an outer reflecting cylinder axially aligned with the inner cylinder and secured to the inner cylinder at its free edge, and a heat reflecting material mounted between the two reflecting cylinders.

4. A heat shielded cathode for gaseous discharge devices comprising, a hollow cylindrical electrode closed at one end by a first disk, a plurality of heater elements adjacent to the outside surface of the hollow electrode for heating the electrode to cause electrons to be emitted from the inner surface thereof, an inner reflecting cylinder having one of its edges coupled mechanically and thermally to the hollow electrode adjacent to its closed end, said inner cylinder positioned adjacent to and surrounding the heater elements, a second disk secured to the other edge of the inner cylinder and having an aperture aligned with the open end of the hollow electrode, and an outer reflecting cylinder axially aligned with the inner cylinder with one edge secured to the inner cylinder adjacent to the periphery of the second disk, and a base disk secured to the other edge of the outer cylinder.

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