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D. V. EDWARDS ET AL

2,111,506

CATHODE STRUCTURE

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Fig. 1

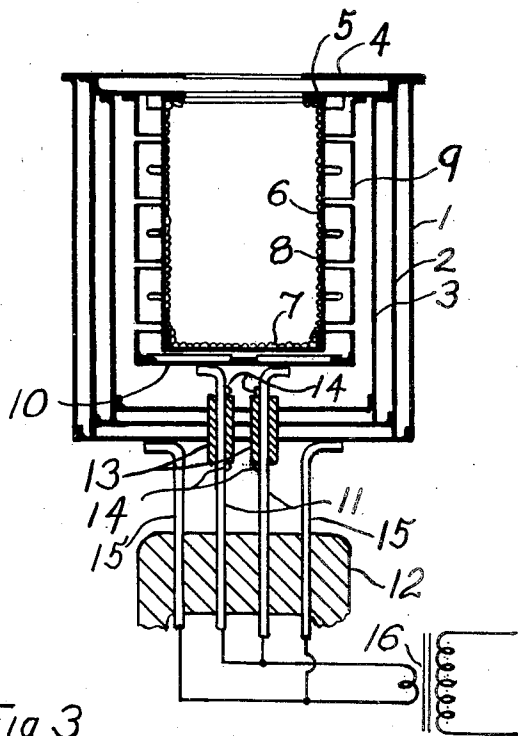


Fig. 2

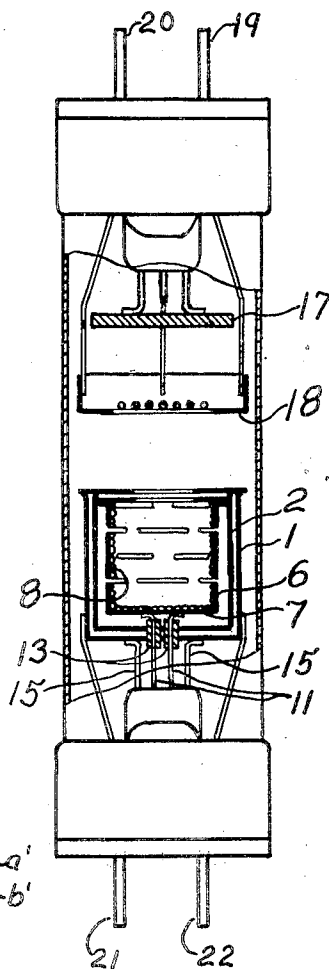


Fig. 3

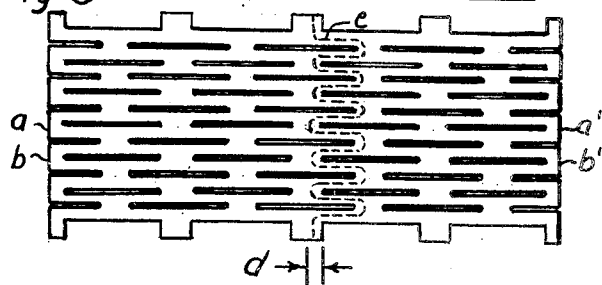
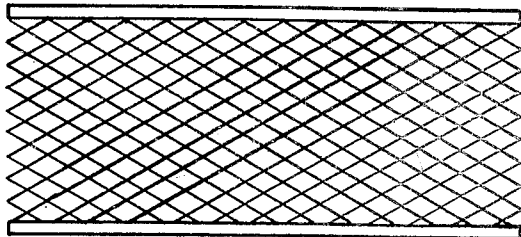


Fig. 4



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CATHODE STRUCTURE

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6 Claims. (Cl. 250—27.5)

This invention relates to hot cathodes for gaseous discharge devices.

The object is to provide a sturdy cathode structure with ample space for ionization near the emissive surface and requiring a minimum of heating power and time required to heat the cathode to emissivity.

In the normal hot cathode discharge device, ionization conditions make a large unobstructed space near the cathode desirable. To meet this requirement the use of externally heated cathodes would be desirable for most tubes of the sizes in use today. Heretofore, however, externally heated cathodes have been avoided because of construction difficulties and also because the required heating time has been too long to be practical. We overcome these difficulties by the structure shown in the accompanying drawing in which:

Fig. 1 shows a cross section of an indirectly heated cathode structure complete with heat shields.

Fig. 2 shows, partly in cross section, a complete tube having a direct heated cathode.

Fig. 3 is a view of the developed surface of the heating element, and Fig. 4 shows a modified form thereof.

The invention will be described with reference to Fig. 1 in which are shown three of the usual heat insulating cans 1, 2, and 3 nested within each other and surrounding the cathode. These should be constructed of a radiant heat reflecting substance such as polished metal and should be spaced out of contact with each other as much as is practicable, only touching at necessary support points in order to limit loss of heat from the cathode by conduction. Two heat insulating covers 4 and 5 are provided. These heat shields are usually fabricated from sheet nickel spot welded together. Welded to the inside cover is the cathode surface 6 having a bottom plate 7. This may be of any suitable metal determined by the chemical requirements of the emissive material used, pure nickel being satisfactory for a great many cases. The coating is painted or sprayed on the inside surface of this cathode. The coating may be of any suitable composition, such as alkaline earth oxides, amphoteric compounds mentioned in Patents 1,817,636, 1,925,701, or the cathode metal may be combined with emissive substances. This is represented schematically in the drawing by the layer 8 although it need not actually be a coating but may be incorporated in the metal body.

The heater 9 is welded at its top end to the cover 5, at its bottom end to the plate 10. Inasmuch as the heater must operate at a higher temperature than the cathode it is usually constructed of a more refractory metal such as tungsten, molybdenum, tantalum or a suitable alloy.

The lead-in wires 11—11, connected in parallel and insulated from the can by sleeves 13—13, of quartz, lava, porcelain or similar material, connect the bottom end of the heater to one side of the power supply which is shown schematically at 16. The sleeves 13—13 are held in place by spot welds on the wires as shown at 14—14. The other side of the power supply returns through leads 15—15, cans 1 and 2, and cover plate 5 to the top end of the heater.

The return from the anode circuit is also connected through leads 15—15, cans 1 and 2, and cover plate 5 to the emissive cathode surface 3.

The most rigid heater structure would be one having a solid sheet rolled into a cylindrical shape. However, such a material with high enough specific resistance and melting point to build the heater in this shape and still have a practical voltage drop is not generally available. It is not desirable to go much below 2.5 volts for the heater power supply because of the cumbersome heating current and also because of the difficulties of designing a winding on the same transformer as the plate winding, which will maintain the cathode heating voltage reasonably accurately. It is, therefore, necessary to find some method of raising the resistance of the heater without seriously sacrificing rigidity.

We accomplish this by cutting slits in the sheet in the manner shown in Fig. 3 which represents a development of the surface of the heater. The sheet of metal from which the heater is to be constructed is slit as shown. The ends are then bent up and welded together so that the point, *a*, is welded to *a'*, *b*, to *b'*, etc. forming a cylindrical surface nearly as strong as the solid sheet. The current flow through the heater must then follow the dotted path, *c*, the length of which is obviously very much greater than it would be if the sheet were not slit. In addition, the width of the current-carrying section has been reduced to a value equal to the distance, *d*, times the number of paths in parallel. In this example eight paths are shown.

By this method it is possible to construct a heater to suit any reasonable voltage without seriously affecting the rigidity of the structure. The rigidity can be increased by making the slits finer, shorter, and more numerous without affecting the voltage rating, although we have found that this is not necessary on tubes of sizes customary today since the heater shown has more than sufficient rigidity.

To keep the heating time as short as possible the weight of material used should be the minimum consistent with sturdy design. It is therefore best to use sheet metal as thin as is practical for the heater 9 and also for the heat shield cans, particularly the inner ones 2 and 3, as their temperature rise is greatest.

The thickness of the cathode is determined by current-carrying capacity, chemical requirements and rigidity. It is, of course, made as thin as is practical.

By this structure we are able to eliminate all insulation material between the heater and cathode. This is an advantage because insulation has a high heat capacity and in addition interferes with the rate of transference of heat from heater to cathode; also because expansion problems prohibit keeping the heater, insulation, and cathode in actual contact in all but very small cathodes.

In Fig. 2 is shown a complete tube having an anode 17, and which may or may not have a control grid 18, the connections of which are brought out at 19 and 20 respectively. The cathode shown here is the direct heated type with connections brought out at 21 and 22. It is the same as shown in Fig. 1 with the exception that the unipotential cathode surface 6 of Fig. 1 with its bottom 7 has been omitted and the coating 8 of Fig. 2 has been applied directly to the inside surface of the heater 8 and its bottom 7. In this case, the heater must be made of a suitable material to receive the coating; for instance, nickel, or an alloy thereof. In Fig. 2 only two heat shielding cans are shown. Due to the lessened heat capacity, this structure is quicker heating. The emissive surface is used nearly as effectively as in the indirectly heated structure and far more effectively than the usual direct heated filament type. Which structure to use depends on the importance of heating time for the particular application involved. Where the direct heated structure is used we prefer to so proportion the slits that the sheath around the emissive surface overlaps and prevents any ions formed from falling through the slits and reaching the heat shield surface.

In some cases it is more convenient to construct the heater or cathode surface by using wire gauze so arranged that individual wires pass down the cylindrical surface in a diagonal manner, as shown in Fig. 4. The length of the heating current path can be increased and the cross section decreased to give a practical filament voltage and still maintain a filament of great rigidity. The individual wires of the gauze do not have to be woven perpendicular to each other. For higher heating voltages, it is preferable to weave them so that the wires make an oblique angle with each other. In this way the length of current path is increased.

The temperature drop between heater and cathode decreases with increasing ratio of heater radiating surface to cathode receiving surface. Our structure is particularly well adapted to maintain this ratio high. As a result we are enabled to use less refractory metal for the heater than is customary with a consequent saving in cost of material and greater ease of manufacture. In addition, we are able to operate the heater at such a low temperature that the life of the heater will be greater than the greatest possible tube life.

We claim:

1. A gaseous vacuum tube device having an anode, a cathode element comprising an emissive surface and an external cylindrical heater element therefor of thin metal cut with staggered openings forming a multiplicity of lengthened current paths, said openings being arranged in number and relative spacing so as to preserve substantial rigidity in said heater element, and a thin metal plate forming the bottom of said

heater element, the said current paths being secured thereto, said heater element being supported solely at one end thereof and at the central portion of said plate.

2. A gaseous vacuum tube device having a cup-shaped cathode and an interior emissive surface, a heater element surrounding said surface and consisting of thin metal cut with staggered openings forming several lengthened current paths arranged so as to preserve the stiffness of said heater element, a thin metal plate connected to said current paths and forming the bottom of said heater element thereby making the heater also cup-shaped, a conductive support common to said cathode and heater at the upper end thereof and a conductive support for the heater secured to the central portion of its bottom plate, said supports constituting the sole support and electrical connections for said heater and cathode.

3. A gaseous vacuum tube device having a cup-shaped cathode with an interior emissive surface and an external heater element therefor consisting of several current conducting paths electrically in parallel and having intermediate points of equipotential interconnected for mechanical support, and a thin metal plate forming the bottom of said heater element, the said current paths being secured thereto, said heater element being supported solely at one end thereof and at the central portion of said plate.

4. A gaseous tube device having a cathode of cylindrical form and an interior emissive surface and a heater element surrounding said surface and consisting of a multiplicity of current conducting paths electrically in parallel and having numerous points of equipotential interconnected for mechanical rigidity, a cup-shaped heat reflecting shield surrounding said heater and cathode surface, said heater element having projections spaced around its top edge and rigidly secured thereby to said shield, and a metal plate forming the bottom of said heater element secured to the lower end of said paths and supported near its center in spaced relation to said shield.

5. A gaseous tube device comprising a hollow cathode having an interior emissive surface and several conducting paths for heater current electrically in parallel and interconnected for mechanical support at intermediate points of equipotential, conductive means secured to the lower end of said current paths and extending across the lower end of the cathode, and a conductive support secured to said conductive means approximately at the center thereof, said cathode being supported solely at its upper end and by said central lower support.

6. A gaseous tube device comprising a hollow cathode having an interior emissive surface and a multiplicity of current conducting paths electrically in parallel and having numerous points of equipotential interconnected for mechanical rigidity, a cup-shaped heat reflecting shield surrounding said cathode and spaced therefrom, said cathode having projections spaced around its top edge and rigidly secured thereby to said shield, a support centrally disposed relative to the lower end of the cathode, and conductive means secured to the lower end of said current paths and extending to said central support, said conductive means being held by said support in spaced insulated relation to the bottom of said shield.

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