May 21, 1940. T. A. ELDER 2,201,721

THERMIONIC CATHODE STRUCTURE

Filed July 11, 1939

Fig. 1.

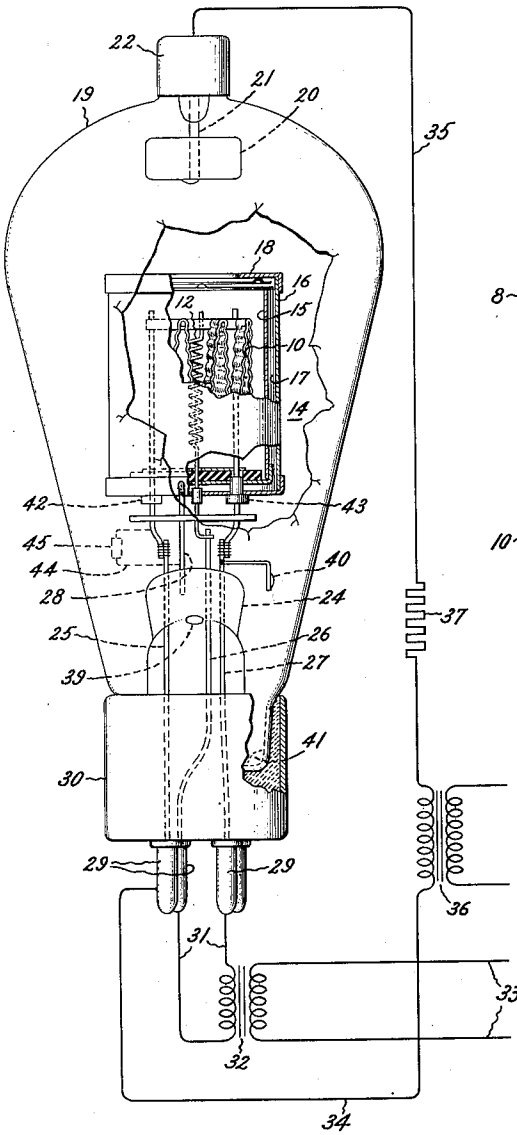


Fig. 2.

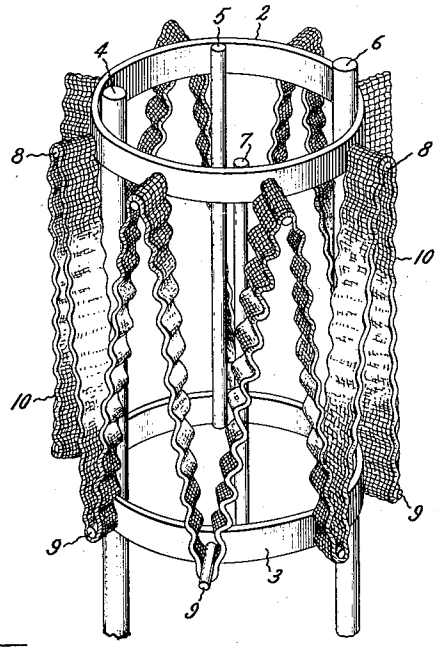
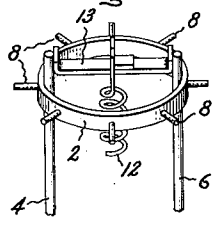


Fig. 3.



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Patented May 21, 1940 2,201,721

UNITED STATES PATENT OFFICE

2,201,721

THERMIONIC CATHODE STRUCTURE

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Application July 11, 1939, Serial No. 283,803

8 Claims. (Cl. 250—27.5)

The present invention comprises improved cathodes for electrical discharge devices, and in particular for heavy duty power devices such as rectifiers and thyratrons for use in the industrial field. It is an object of my invention to provide thermionic cathodes of rugged construction and large emitting surface which are capable of being heated quickly and efficiently to electron-emitting temperature.

My invention is applicable in particular to electrode structures in which elongated cathode members, such as ribbons, are embodied which are maintained at electron-emitting temperature by radiant heat. Such structures should be mechanically rugged and supported so firmly that disarrangement of parts which might establish contact between the heater and the emitting surfaces is precluded. In power devices particularly, thermionic cathodes should provide for an open path to the anode for the electron discharge from all parts of the emitting surfaces of the cathodes. A generally radial arrangement of such surfaces as herein shown provides an open path.

It is particularly desirable that the heavy duty cathodes in power tubes should be substantially unipotential in order that the load current will be equally distributed over the emitting area. It is further desirable that the electron-emitting members should be maintained at operating temperature with the least expenditure of heating energy. As will be shown, these and other desirable features are present in cathodes embodying my invention.

As will be pointed out with greater particularity in the appended claims, cathode constructions embodying my invention are characterized by the combination of a cathode framework providing a plurality of supports located in different planes upon the periphery of which one or more elongated members are mounted and constitute a unipotential electrode of open structure having generally planar emitting surfaces of substantial area. A cathode heater is supported within such cathode which is surrounded by a heat-conserving enclosure.

An embodiment of my invention is illustrated by the accompanying drawing in which Fig. 1 is a side elevation of a rectifier in which an improved cathode assembly is shown, partly in section; Fig. 2 is a perspective view on an enlarged scale of an electron-emitting cathode structure embodying my invention; and Fig. 3 illustrates a constructional detail.

Referring to Fig. 2, the cathode framework comprises two rings 2, 3, which are held in spaced relation by electrically conducting rods 4, 5, 6 and 7. The rings 2, 3 which may consist of metal, such as nickel for example, each are provided with a plurality of radially projecting supports or pins, which may consist of a more refractory metal, such, for example, as molybdenum.

The pins, carried by the upper ring 2, which are designated by the numeral 8, and the pins, carried by the lower ring 3, which are designated by the numeral 9, are arranged in staggered relation to one another as shown. A crimped ribbon 10 is looped back and forth over these pins and forms a series of V-shaped loops arranged in spaced zigzag relation to form a cage-shaped structure with relatively wide spacing between the ribbon elements. As will be observed from the drawing, corresponding edges of the electron-emitting cathode elements, that is, the adjacent inner edges and the adjacent outer edges respectively, of the ribbon 10 are spaced apart from one another, leaving relatively wide openings therebetween. Preferably the cathode ribbon is fastened to the two sets of pins 8 and 9 by spot welding, or otherwise, although in some cases frictional contact will be sufficient to hold the ribbon in place. The ribbon 10, which may consist of nickel, molybdenum, or other suitable metal, preferably is coated or otherwise activated to increase electron emissivity. Ordinarily it is coated with alkaline earth oxide, such as barium, strontium or calcium oxide, or a mixture of such oxides, in accordance with well understood practice.

Although the drawing shows a continuous length of cathode ribbon, it is immaterial whether the ribbon consists of a single length draped back and forth over the pins and fastened thereon, or whether it consists of a plurality of sections which are electrically connected to the conducting framework. In either case a unipotential annular structure, mechanically and electrically connected at numerous points, will result. In such a structure the discharge current does not concentrate at a region near a terminal, which would result in shortened life.

Although a crimped ribbon is preferred for the purposes of my invention, other generally planar forms of emitting structures not only uncrimped but otherwise differing from the form shown may be used. A plurality of filaments arranged side by side could be used to constitute a desired planar structure. The emitting structure may be twisted or otherwise modified in shape. As indicated in the drawing, wire gauze may be used

as the base member which is coated with activating material. Likewise, gauze may be applied to the surface of a solid ribbon to assist in maintaining coating material in place and to increase the surface, or a plain metal ribbon or a perforated metal ribbon may be used.

The ribbon cathode is heated by radiation to an electron-emitting temperature, for example, to about 850 to 950° C. For this purpose a helical filamentary heater 12, Figs. 1 and 3, is provided in the space enclosed by the cathode. This heater, which may consist of tungsten, or other suitable refractory material, may be supported at one end by a transverse bar 13 (Fig. 3) which is joined by welding or otherwise to the supports 4 and 6, or is supported otherwise by the cathode framework.

As shown in Fig. 1, the cathode ribbon is surrounded by a metal heat shield 14, shown partly broken away and in section. It preferably is a structure providing spaced walls 15, 16, between which are located a plurality of layers of metal foil 17 held in loosely spaced relation as described in U. S. patent application Serial No. 243,101, filed November 30, 1938. The heat shield is described in British Patent No. 383,645 of November 24, 1932. The effective heat insulation of such a structure is greater than a single-walled shield, or a shield with a lesser number of walls. As a consequence, the inside wall of the shield is so highly heated that the cathode receives heat effectively by radiation from the highly heated inner shield wall as well as from the primary heater 12. The shield also includes an apertured cover 18.

Fig. 1 shows the cathode and appurtenant parts mounted in a bulb 19. There is provided as usual also an anode 20 which is connected by a lead 21 to an external contact 22.

The assembly comprising the cathode and the heat shield is mounted on a glass stem 24 by the sealed-in conductors 25, 26 and 27, and the shield support 28. The conductors 25, 26 and 27 are connected to the usual external contact plugs or prongs 29. The base 30 is of conventional structure.

In a rectifier only three external contacts are required, the fourth merely serving to properly orient the plugs in the socket. Should the device contain also a grid (not shown), then the grid conductor is connected to one of the contact plugs. Two conductors, for example, 26, 27, conduct energizing current to the heater filament. These conductors are connected to the external circuit 31 which contains a suitable source of current such as the secondary of a transformer 32, the primary of which is supplied by the conductors 33. The third conductor 25 leads to the cathode only and serves to carry load current. It is connected to the external conductor 34. The load conductors 34 and 35 are connected to a transformer 36, the load being represented by a resistance 37.

The bulb 19 is freed from water vapor and is evacuated in the usual manner through the exhaust opening 39, a getter in a capsule 40 being provided to remove residual gas. The bulb is charged before sealing with a low pressure gas or vapor. For example, a small globule of mercury may be provided as indicated at 41, the pressure of mercury vapor at an operating bulb temperature of 40 to 60° C. being about 6 to 24 microns. However, the described construction is not limited to a specific pressure of ionizable medium.

The shield 14 does not take part in the emission of electrons. Insulators 42, 43 are provided at the bottom and the heater conductor 26 passes through a clearance hole in the bottom of the inner shield wall as indicated. The shield 14 may be connected to the cathode by a circuit 44 containing a high resistance 45 (for example, 10,000 ohms or more), or this circuit and the resistor may be omitted, the shield being electrically insulated from the electron-emitting cathode.

My invention, however, does not require as an essential feature any particular form of heat shield structure.

While my improved cathode has been illustrated in connection with a rectifier, that is, a two-element device, I wish it to be understood that it can be used in discharge devices having additional elements.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A thermionic cathode for electric discharge devices comprising supports spaced apart, a continuous ribbon providing a plurality of zigzag activated metallic ribbon elements mounted on the periphery of said supports to form a cage-shaped structure, said ribbon elements having generally planar emitting surfaces and being arranged spaced apart with openings between adjacent edges, and means for heating said ribbon elements to an electron-emitting temperature.

2. A thermionic cathode comprising a linearly extending heater, a mounting framework having two sets of radially extending supporting means arranged in axially displaced planes adjacent opposite ends of said heater, a substantially continuous metallic structure mounted around said heater in a zigzag course over and between said supporting means, said metallic structure being of such character as to define by its various zigzag sections a plurality of radially extending and generally planar emitting surfaces of substantial area.

3. In an electrical discharge device an assembly comprising an elongated ribbon-shaped electron-emitting cathode, an electrically conducting framework therefor providing a plurality of outwardly extending supports spaced apart in different planes, said cathode being mounted in a zigzag arrangement upon said supports thus forming a unipotential structure, an electrically insulated heat-conserving enclosure therefor and heat-radiating means for heating said cathode to an electron-emitting temperature.

4. In an electrical discharge device an assembly comprising the combination of a framework consisting of conductive support members spaced apart, longitudinal rods mechanically and electrically connecting said members to one another, a plurality of pins projecting outwardly from said members, an elongated planar electron emitter supported by said pins as a zigzag structure spaced about said rods, means for heating said electron emitter by radiant heat, and an electrically insulated, aperture heat shield surrounding said electron emitter.

5. In an electrical discharge device an assembly comprising a spool-shaped support including a pair of annular metal rings connected together by metal tie rods extending at right angles to the planes of said rings, said rings each being provided with a plurality of outwardly projecting pins, a metal ribbon wound in a zigzag course over said pins, said ribbon being welded to said pins at the regions of contact, a filamentary heater, means for supporting said heater in an axial position with respect to said ribbon and

a heat-conserving enclosure closely surrounding said ribbon.

6. A structural asembly for an electrical discharge device comprising an apertured heat shield, a filamentary radiation heater supported therein, substantially in line with the longitudinal axis of said shield, a framework within said shield providing a plurality of sets of supporting rings surrounding said heater, a set of outwardly projecting pins on each of said rings, said sets of pins being spaced in staggered relation to one another, an electron emitter comprising an elongated meandrous crimped ribbon supported by and electrically joined to said pins, thereby forming a substantially unipotential structure, a coating of material on said ribbon capable of increasing electron emission, an energizing circuit for said heater and a load circuit cathode terminal which is independent of said heater circuit.

7. A thermionic cathode comprising the combination of a supporting structure including a pair of metal rings, elongate metal rods connecting said rings, and pins outwardly projecting from said rings, an elongate filamentary heater, means for supporting said heater axially within said structure, and electron-emitting ribbon elements supported on said pins in unobstructed radiation-receiving relation to said heater, said ribbon elements extending between said rings in spaced relation with respect to one another, the sides of said ribbon elements being substantially radially arranged with respect to heater.

8. A structural assembly for an electrical discharge device comprising the combination of two sets of radially projecting supports spaced apart in different planes, an electron-emitting ribbon mounted in a series of loops on said supports, an elongated radiant heater extending between said supports in the space enclosed by said loops, and an enclosing heat shield, said ribbon having a generally planar surface and being arranged substantially radially about said heater with corresponding edges of contiguous sections spaced apart from one another leaving openings whereby said ribbon is in direct receiving relation for heat radiated from said heater and reradiated by said heat shield.

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