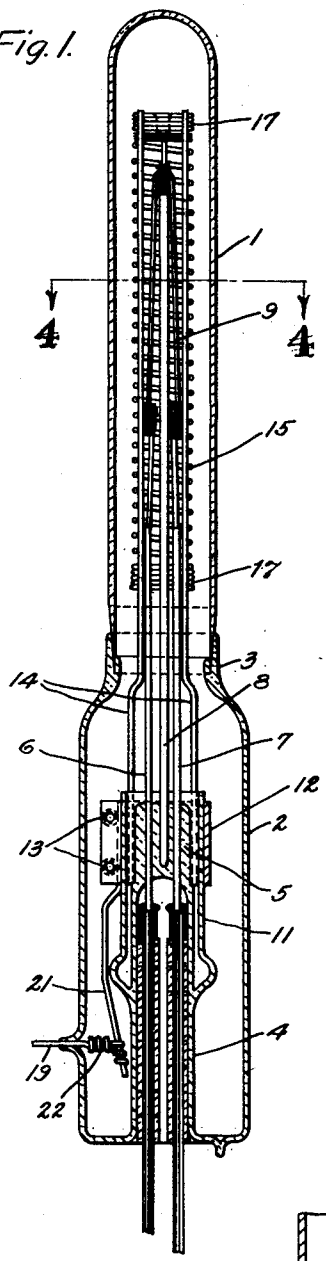
March 3, 1931. W. G. WADE 1,794,933

TRIODE VACUUM TUBE

Filed Nov. 22, 1924

Fig. 1.



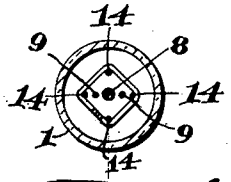
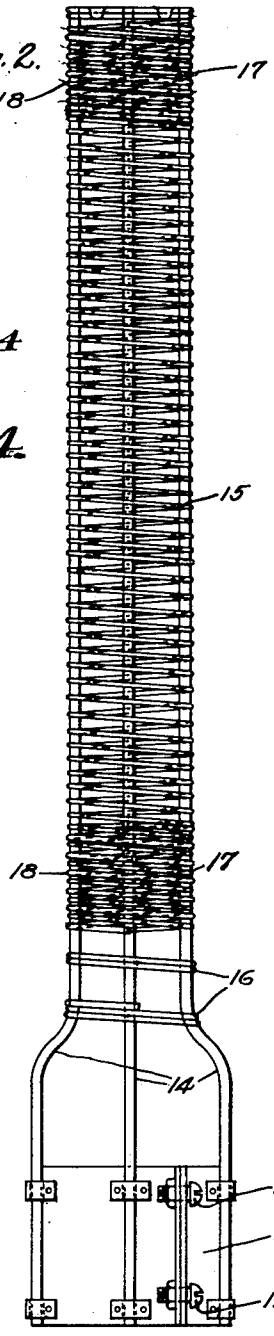




Fig. 4.

Fig. 2.



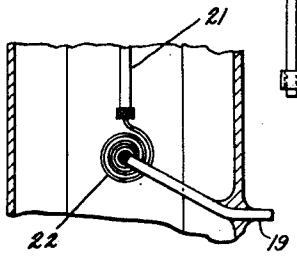




Fig. 3.

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Patented Mar. 3, 1931

1,794,933

# UNITED STATES PATENT OFFICE

WALLACE G. WADE, OF LANCASTER, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

## TRIODE VACUUM TUBE

Application filed November 22, 1924. Serial No. 751,510.

My invention relates to thermionic discharge devices and particularly to such devices as are adapted for the utilization of large powers.

An object of my invention is to provide an improved thermionic discharge device in which provision is made for artificial cooling thereof.

Another object of my invention is to provide an improved thermionic discharge device having an anode, one surface of which is exposed to suitable cooling media, the other surface of which is adapted to receive an electron stream.

Another object of my invention is to provide a thermionic discharge device in which the anode is a portion of the evacuated container and in which the metallic anode is attached by an edge seal to a glass closure.

Another object of my invention is to provide a thermionic discharge device having a control electrode which is self-supporting.

Another object of my invention is to produce a thermionic discharge device in which is provided a truss-type electrode for the control of an electron stream.

Another object of my invention is to provide convenient means for the assembling of a thermionic discharge device in which the electrodes are connected by conductors through glass-to-metal seals with outside circuits.

In the prior construction of thermionic discharge devices, it has been customary to provide them with a hot electrode and a cold electrode suitably positioned and mounted within a glass container. In these devices, connection is made to the various electrodes by means of wires sealed through the glass envelope. Devices so constructed are found to be available for limited powers only, since it is found that the unavoidable loss of energy in the course of the translation of energy by the device, heated the device to a temperature which caused destruction thereof, if more than very small powers were passed therethrough. The heating occurred very largely at the anode which should have been kept cool, and upon the application of overload, not infrequently a point was reached where the anode metal was fused.

Attempts have been made to produce thermionic discharge devices of such a construction that artificial cooling means could be applied to one surface of the anode. Great difficulty has, however, been experienced in this attempt because of the difficulty of producing a structure which remains gas tight.

Likewise in the prior art, great difficulty was experienced in constructing a control electrode of sufficient strength and rigidity to retain its shape and position under the forces acting during the operation of the device. Difficulty has also been experienced in the assembly of such devices in making the connection to electrodes therein.

My invention provides a construction for an improved thermionic discharge device in which an anode is adapted to have its outer surface cooled by artificial cooling means, while its inner surface receives an electron stream. My device is readily assembled through the use of an edge seal between the metal anode and the glass closure which forms the other part of the evacuated envelope as disclosed by Kirwer, Serial No. 665,415, filed Sept. 28, 1923 (Case 10688) and assigned to the Westinghouse Electric & Manufacturing Company. My invention further provides a very rugged control electrode and convenient means for connecting the control electrode to the outside circuit.

Other objects and structural details of my invention will be apparent from the following description when read in connection with the accompanying drawings, wherein:

Figure 1 is a view in vertical section of an embodiment of my invention,

Fig. 2 is an enlarged view in elevation of a grid electrode structure thereof, and

Fig. 3 is a fragmentary view showing an alternative means of connecting the grid electrode of my invention with the outside circuit.

Fig. 4 is a sectional view transverse to the tube about midway of its length.

Referring to the drawing, 1 is a cylindrical anode, an end of which is capped or closed over by any convenient means which produces a gas-tight closure. This may be secured by brazing on a cap or by drawing the cylinder from an integral disc of metal leaving the end thereby closed. The open end of the cylinder 1 has its periphery thinned to practically a knife edge. A glass portion 2 is sealed to the anode cylinder 1 at its thinned edge to form an edge seal 3 in the manner disclosed by Kirwer. The glass member 2 is provided with a re-entrant portion 4 and a press 5 thereon.

Through the press 5 are sealed cathode lead wires 6 and 7 and a cathode supporting wire 8 supporting the filamentary cathode 9. A glass sleeve 11 is attached to the re-entrant portion 4 surrounding the press 5. Upon sleeve 11 is positioned a band 12 adapted to be clamped thereto by bolts 13. The band 12 supports a plurality of upright members 14 to which in turn is attached a helical wire member 15 having its turns suitably spaced. The member 15 is preferably attached by welding each turn thereof to each of the uprights 14. Strengthening bands 16 and 17 that are provided, are also attached to members 14, preferably by welding.

The strengthening bands 17 are built up to greater rigidity by the addition of a wrapping of fine wire 18 as shown in greater detail in Fig. 2. A seal wire 19 is provided at a suitable point through glass envelope portion 2 and a lead conductor 21 attached to band 12 is positioned in close proximity thereto. Connection between seal wire 19 and lead 21 is made by an elastic coiled member 22 which may be helical in form as shown in Fig. 1 or of spiral form as shown in Fig. 3.

The cylindrical anode may be surrounded by any desiring cooling means, which may be a blast of air, or preferably a stream of water or oil, within any suitable container surrounding the anode.

In the construction of my device, the anode cylinder 1 is cleaned by suitable chemical treatment to remove adhering dirt, grease and oxide. The edges of the open end are then thinned, over a length of about an inch and a quarter, to produce a taper from the original thickness of the tube to a thickness of 1 or 2 thousandths of an inch at the extreme edge. The glass blank is then prepared by blowing a bulb of suitable size thereon. The thinned edge of the copper anode 1 is then oxidized slightly, the hot glass adjusted in position against it and worked both within and without until a collar of glass is provided, which thoroughly wets the surface of the copper cylinder, both inside and outside, over a distance ranging from $\frac{3}{16}$ to $\frac{3}{8}$ of an inch. To this glass collar a suitable glass envelope of the indicated size and shape may then be welded or sealed. This procedure produces an adherent seal between glass and metal which is gas tight, and resistant to baking and to temperature changes.

The cathode structure may next be prepared by inserting seal wires 6 and 7 and supporting wire 8 within a tube of a size suitable to form re-entrant portion 4, by heating and forming a press thereon in the manner well known in the prior art. The seal wires 6 and 7 may then be attached to a suitable cathode structure as disclosed in my co-pending application, Serial No. 751,508 filed Nov. 22, 1924, and assigned to the Westinghouse Electric and Manufacturing Company.

The grid structure 15 may next be assembled. Wires 14 are bent to the indicated shape and positioned upon a mandrel. The band 12 may be attached to wires 14 by welding or riveting, or other suitable fastening with or without weld strengthening heat members as desired. The helical grid wire 15 may then be coiled upon wires 14 around the mandrel and fastened by welding or otherwise attaching wire 15 to wires 14 at each crossing point. Strengthening bands 16 and 17 of heavier wire may then be wrapped in place and likewise attached, preferably by welding. Additional strengthening means is then provided by a wrapping of fine wire 18 wound at random thereabout.

The helix 15 is the electron stream control means and is used, as in the prior art, but because of the very high electrostatic forces acting on it and produced by the high voltages applied to the tube, it must be vary stiff, in order to retain its position and spacing with respect to the cathode and anode. A certain amount of stiffness is provided by the lengthwise wires 14 of which it is usual in the art to provide one or two. In this embodiment four lengthwise wires are provided, which are individually attached to the turns of the helix wire. This gives a construction which corresponds to a box girder, and makes a very rigid truss structure, of a stiffness far in excess of that of any previous grid construction, and very much greater than would result from simply doubling the number of lengthwise wires. The stiffness is further increased by the addition of the extra strengthening bands at each end of the helix which furnish a foundation stiffening for the girder structure. By this construction a truss structure for a grid is obtained of such stiffness that the section which serves on the electron stream control is self supporting under the applied electrostatic forces.

Lead wire 21 may then be attached to the grid assembly in any suitable way. To conductor 21 is next attached the elastic con-

ductor 22 and seal wire 19 which may have been previously beaded with glass. The grid assembly member comprising wires 14, collar 12, bands 16 and 17 and the helix 15 may then be positioned upon collar 11, which has previously been attached to tube 4, and then adjusted until it is concentric with the axis of the cathode filament structure 9. This portion of the device comprises the mount.

The mount may then be inserted within the anode 1 and glass envelope 2 and seal wire 19 inserted through a previously formed opening in envelope 2. The mount may then be attached by sealing the tube 4 to the envelope 2 in the usual way, and the grid 15 and cathode 9 concentrically positioned within anode 1 while the seal is soft. The glass surrounding the opening through which seal wire 19 has been inserted may then be fused and sealed to the wire 19.

The fusing of the mount of the envelope 2 may be accompanied by the insertion of an exhaust tube as is common in the prior art.

The device may then be evacuated to the desired degree, which may desirably be to a pressure of approximately $1 \times 10^{-3}$ or $10^{-4}$ millimeters of mercury by suitable evacuation, heating, baking, and treating means, upon the completion of which the device may be sealed off from the pump system in the manner common in the prior art.

In the operation of my invention, it has been possible, with an anode structure of a cylinder approximately an inch and a quarter diameter and 8 to 10 inches long, and a cathode structure of two looped filaments approximately 0.025 inches in diameter and 8 inches long, to handle approximately 10 kilowatts energy input. This energy may be received in the form of alternating current and may be rectified to the form of direct current, in which case the grid structure 15 may be omitted. Or the energy may be in the form of direct current and may be converted to alternating current which may be of radio frequency in the manner well known in the art, in which case, the grid 15 must be present.

By the construction embodied in the device of my invention, it has been found possible to produce a thermionic discharge device which is easily assembled, is rugged, is resistant to load forces while in operation, and which has a relatively longer life than other similar devices of the prior art and which is suitable for the translation of much higher powers than have been possible with similar devices of the prior art.

While I have shown only one embodiment of my invention in the accompanying drawings, it is capable of various changes and modifications without departing from the spirit thereof, and it is desired, therefore, that only such limitations shall be placed thereon as are imposed by the prior art or indicated in the appended claims.

I claim as my invention:

1. A thermionic discharge device comprising in combination an anode, a grid, a cathode and a container having a re-entrant portion, said grid comprising a wire helix having spaced turns, lengthwise members of heavier wire attached thereto, and strengthening bands of wire heavier than that in said helix attached to said lengthwise members, forming a strengthened box girder truss structure.

2. A thermionic discharge device comprising in combination an anode, a grid, a cathode and a container having a re-entrant portion, said grid comprising a wire helix having spaced turns, lengthwise members of heavier wire attached thereto, and strengthening bands of wire heavier than that in said helix attached to said lengthwise members, forming a strengthened box girder truss structure, and a band of sheet metal attached to conjugate ends of said lengthwise members and adapted to surround said re-entrant portion and support said grid structure therefrom.

3. A thermionic discharge device comprising in combination, an anode, a cathode, and a grid electrode comprising a lengthwise member, and a helix of spaced turns of wire attached thereto, said lengthwise member comprising in itself a stiffened truss structure.

4. In an electron-discharge device comprising an elongated cathode, a grid structure comprising three or more rigid metallic posts bounding a prismatic tubular space around said cathode and extending into a space removed from said cathode, a substantially rigid support holding said posts at the portion removed from said cathode, a plurality of windings of heavy wire surrounding said posts at two or more spaced portions along the length thereof and rigidly secured thereto, said posts and wire windings constituting a substantially rigid prismatic framework permitting substantially unobstructed flow of electrons from said cathode into the space outside said framework, and windings of relatively fine grid wire supported on said posts throughout the space surrounding said cathode.

5. In an electron-discharge device comprising an elongated cathode, a grid structure comprising three or more rigid metallic posts bounding a prismatic tubular space around said cathode and extending into a space removed from said cathode, a substantially rigid support holding said posts at the portion removed from said cathode, a plurality of windings of heavy wire surrounding said posts at two or more spaced portions along the length thereof removed from said cathode and rigidly secured to said posts, said posts and wire windings constituting a substantially rigid prismatic framework permitting substantially unobstructed flow of electrons

from said cathode into the space outside said framework, and windings of relatively fine grid wire supported on said posts throughout the space surrounding said cathode, said windings of fine wire overlapping the portions of the posts carrying the windings of heavy wire.

In testimony whereof, I have hereunto subscribed my name this 20th day of November, 1924.

WALLACE G. WADE.