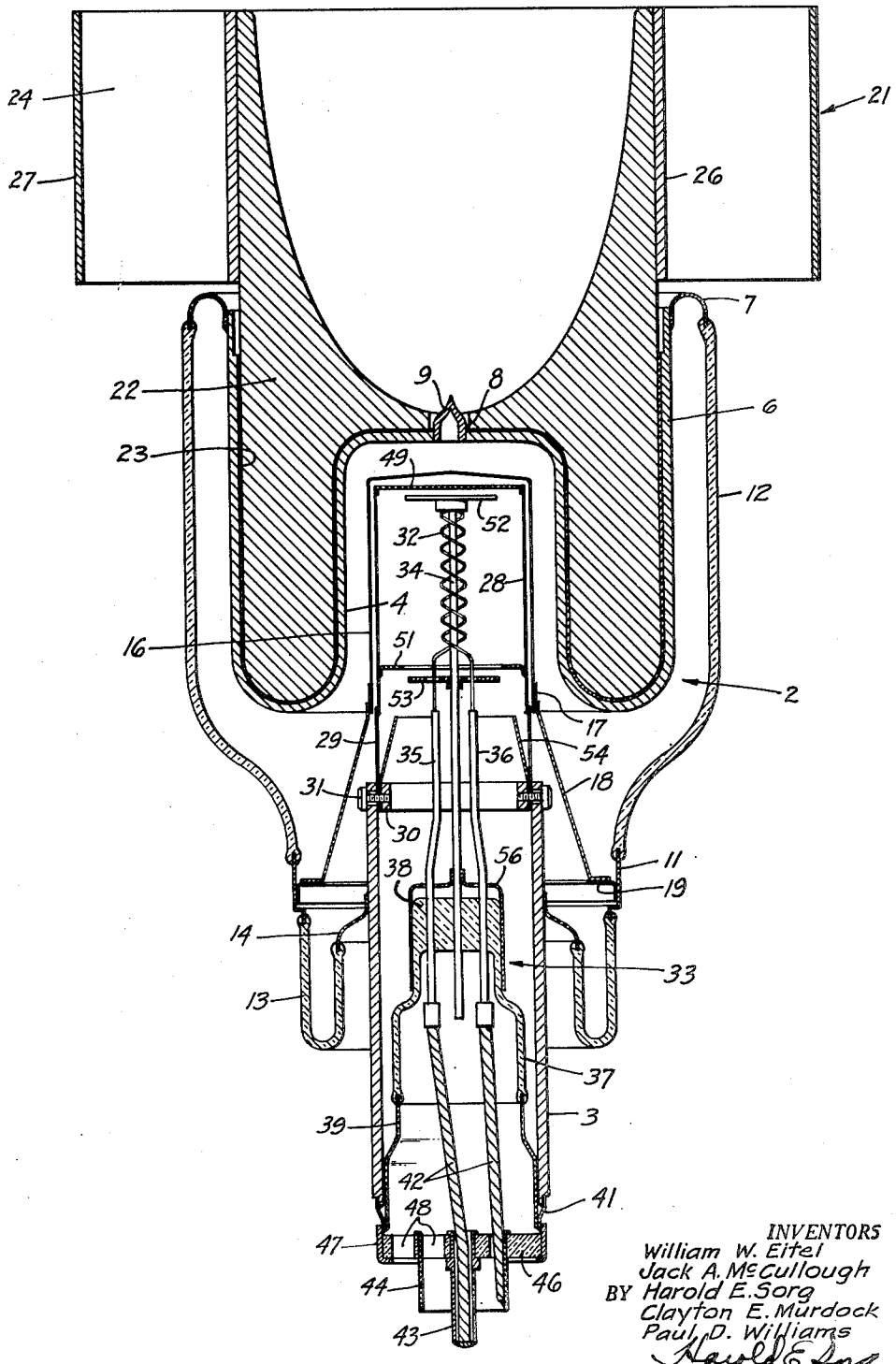
Sept. 7, 1954 W. W. EITEL ET AL 2,688,707

ELECTRON TUBE STRUCTURE

Filed Feb. 28, 1948



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Patented Sept. 7, 1954 2,688,707

UNITED STATES PATENT OFFICE

2,688,707

ELECTRON TUBE STRUCTURE

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Application February 28, 1948, Serial No. 11,916

9 Claims. (Cl. 313—37)

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The broad object of our invention is to provide a tube structure having improved power capabilities in the higher frequency ranges.

Another important object is to provide a tube of the character described embodying an improved cathode structure having the physical and electrical attributes required for pulse operation such as in radar transmitters.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of our invention. It is to be understood that we do not limit ourselves to this disclosure of species of our invention, as we may adopt variant embodiments thereof within the scope of the claims.

Referring to the drawing the single figure is a vertical sectional view of a tube structure embodying the improvements of our invention.

In terms of broad inclusion, our electron tube structure comprises an envelope, a cathode in the envelope comprising a thoriated tungsten sheet, preferably of cylindrical shape, and means in the envelope for uniformly heating such cathode sheet to its operating temperature. In our preferred construction the heating means comprises a filament, preferably of unthoriated tungsten, for heating the thoriated tungsten sheet by electron bombardment, a terminal being provided on the envelope for the cathode sheet and separate terminals being provided for the filament. The cathode terminal is preferably a tubular member at one end of the envelope upon which the cylindrical cathode sheet of thoriated tungsten is coaxially mounted, and the filament terminals are preferably brought out through a stem in the cathode terminal. In a triode particularly designed for high power operation in the upper frequency ranges the anode is preferably a reentrant external anode located at the envelope end opposite the cathode terminal, and the grid is mounted on a grid terminal ring interposed in the envelope wall between the anode and the cathode terminal.

In greater detail, and referring to the drawing, our tube structure comprises an evacuated envelope having an external anode 2 at the upper end and a tubular cathode terminal 3 at the lower end. The anode is of metal such as copper and is preferably of reentrant shape having a cylindrical cup-shaped body 4 and an integral upturned flange 6 terminating in a downturned sealing ring 7. By this arrangement the sealing ring 7 is located well above the lower end of the main anode body 4, the reentrant portion of the anode

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forming an open annular cavity or space between the body 4 and flange 6. A metal exhaust tubulation 8 on the anode body 4 is pinched off at tip 9 after evacuating the envelope.

A metallic grid terminal ring 11 is arranged below the anode, and an envelope section 12 of vitreous material such as glass is sealed at its upper end to sealing ring 7 and at its lower end to grid terminal ring 11. Since glass section 12 extends upwardly to the upper end of anode flange 6 an ample glass path is provided between the anode and grid terminal ring for high voltage insulation purposes. Another glass envelope section 13, preferably of U-shape, is sealed along its outer periphery to the lower edge of grid terminal ring 11 and along its inner periphery to a sealing flange 14 on the cathode terminal 3. As shown, the cathode terminal projects downwardly beyond the envelope section 13 to provide ample contact surface for circuit connection, the terminal 3 being preferably of copper.

In the triode type of tube illustrated the control grid 16 projecting into anode body 4 is preferably of cage construction having longitudinal wire bars terminating at a base ring 17 and supported by a conical metal bracket 18 on a flange 19 secured to grid terminal ring 11. This grid terminal arrangement brings the grid connection out on the envelope wall at a point intermediate the anode and cathode terminals which is desirable from the circuit standpoint, it being noted that the anode, grid terminal ring and cathode terminal are all coaxial for fitting into high frequency linear circuits. It is understood that if a tetrode type of tube is desired a second grid terminal ring can be provided on the envelope for supporting a screen grid.

A cooler 21 for forced air cooling comprises a core 22 of copper or aluminum having an annular lower portion projecting into the annular cavity formed by the reentrant portion of the anode and secured as by cadmium solder 23. The upper portion of the core carries cooling fins 24 extending radially between retaining sleeves 26 and 27. This cooler structure is preferably soldered to the anode after the tube envelope has been exhausted. While air cooling is preferred it is understood that a water cooling jacket may be used, in which case the cooling jacket preferably extends into the reentrant portion of the anode.

The cathode in our improved tube comprises a cylinder 28 of thoriated tungsten sheet. The cathode cylinder is preferably fabricated of pure tungsten and then thoriated and carburized in accordance with the process disclosed in the co-

pending application of Paul D. Williams, Serial No. 4,648, or may be any other type of cathode material known in the art. This cathode cylinder is arranged coaxially with the cathode terminal 3 and is supported on the latter by a sleeve 29. The supporting sleeve is preferably of tungsten welded to the cathode cylinder and secured to the upper rim of the cathode terminal in a suitable manner, as by a clamping ring 30 held by screws 31. This cathode structure provides a low inductance path from an external point directly to the thoriated tungsten emitting surface.

The means for heating cathode cylinder 28 preferably comprises a filament 32 arranged to heat the thoriated tungsten sheet by electron bombardment. A helical filament of unthoriated tungsten wire is preferably employed and is arranged to project coaxially within the cathode cylinder, a bifilar filament being preferred. This filament is supported from a stem 33 within the cathode terminal 3 and having three upwardly projecting tungsten rods 34, 35 and 36. The center rod 34 extends through the filament and is welded to the upper ends of the filament strands, while the two shorter rods 35 and 36 are welded to the lower ends of the filament strands.

Stem 33 preferably comprises a tubular glass section 37 having a press 38 through which the rods 34, 35 and 36 are sealed. The lower end of glass section 37 is sealed to a metal sleeve 39 which in turn is secured to a flange 41 on the lower end of the cathode terminal 3. All of the metal-to-metal connections are preferably brazed to insure vacuum tight joints. Flexible extensions 42 on the lead-in rods 35 and 36 are connected to concentric terminals 43 and 44 supported by an insulating disk 46 fastened to the end of cathode terminal 3 as by a retaining ring 47. The filament terminal 43 is preferably a pin located centrally of the tubular filament terminal 44, it being noted that these filament terminals are both coaxial with the cathode terminal 3 so that all fit with coaxial line circuitry.

By this arrangement separate terminals are provided for the filament 32 and there is no interference with the cathode circuit because the filament connections are brought out through the hollow cathode terminal. Suitable air passages 48 are preferably provided in disk 46 to permit forced air circulation in the stem structure. In the operation of our tube a source of current is connected to the terminals 43 and 44 to heat the filament to its electron emitting temperature, and the cathode cylinder 28 is maintained at a sufficiently positive potential with respect to the filament to effect heating of the thoriated tungsten sheet to the desired temperature by electron bombardment from the filament. The operating temperature of the cathode cylinder 28 is preferably around 1650° C. brightness temperature, and the operating temperature of filament 32 (using unthoriated tungsten wire) is preferably around 1800° C.

In the interest of thermal efficiency the ends of the cathode cylinder are confined by suitable heat shielding. This is done by completely closing the upper end of the cylinder with a tungsten cap 49 welded to the cylinder wall, and by providing an apertured tungsten disk 51 welded at the lower end of the cathode cylinder. Disks 52 and 53 mounted on the center rod 34 adjacent the upper and lower ends of the cathode cylinder complete the shielding arrangement. The lower disk 53 cooperates with the apertured piece 51 for closure purposes and the upper disk 52 protects the cap 49 against excessive bombardment. These disks 52 and 53 are preferably of carbon or graphite to suppress electron emission from their surfaces. Flared skirt 54 projecting from the base of supporting sleeve 29 provides still further shielding. A thermally efficient cathode is thus obtained and, what is equally important, uniform heating of the cathode cylinder 28 along its active length is assured. These are very important considerations in a thoriated tungsten cathode of the character described because of the relatively high operating temperatures involved. A metal cup 56 secured to center rod 34 and fitted over the inner end of stem 33 protects the glass of the stem against heat and stray electron bombardment.

With tube structures made in accordance with the teachings of our invention we have obtained tube performances greatly exceeding those obtainable with tube structures heretofore known. The improved performance is due partly to the general envelope structure and electrode supporting and terminal arrangement, particularly at the cathode end of the tube, but primarily to the improved cathode and heater structure embodied in the tube. It is true that tubes with unipotential surface or cylindrical type cathodes having oxide coatings are well known, but these oxide coated cathode tubes will not operate under conditions involving high voltage gradients and ion bombardment. It is also true that thoriated tungsten in the form of wire has long been used to make filament type emitter structures, many varieties of filaments of the helical and longitudinal strand type having been developed to utilize thoriated tungsten in its available wire form. Such filaments are reasonably satisfactory for some tubes but are wholly unsuited for high power high frequency tubes because of limited electron emission, mechanical weakness and limitations on frequency inherent in the filamentary or strand-like nature of the filament structures. Our improved tube materially lifts the ceilings on frequency and power levels imposed by electron tube structures heretofore known, particularly in connection with pulse applications such as radar use. The improved tube works well either as an oscillator or as an amplifier, and is well adapted for C. W. use as well as for pulse service.

We claim:

1. An electron tube structure comprising an envelope having a tubular cathode terminal at one end, a cathode in the envelope comprising a cylinder coaxial with and connected to said terminal, a filament in the envelope and projecting into the cathode cylinder for heating said cylinder by electron bombardment, and separate terminals for the filament coaxial with the cathode terminal extending outwardly of the envelope through said cathode terminal.

2. An electron tube structure comprising an envelope having a tubular cathode terminal at one end, a cathode in the envelope comprising a cylinder including thoria and tungsten sheet coaxial with and connected to said terminal, a filament in the envelope and projecting into the cathode cylinder for heating said cylinder by electron bombardment, a stem supported by said cathode terminal, and conductor rods projecting from the stem and supporting said filament.

3. An electron tube structure comprising an envelope having a tubular cathode terminal at one end, a cathode in the envelope comprising a cylinder including thoria and tungsten sheet

coaxial with and connected to said terminal, a helical filament of tungsten wire in the envelope and projecting into the cathode cylinder for heating said thoria and tungsten sheet by electron bombardment, a stem supported by said cathode terminal, and tungsten conductor rods projecting from the stem and supporting said filament.

4. An electron tube structure comprising an envelope having a tubular cathode terminal at one end and an external anode at the other end, a grid terminal ring interposed in the envelope wall between the anode and said cathode terminal, a grid in the envelope extending into the anode and connected to said grid terminal ring, a cathode in the envelope extending into the grid and comprising a cylinder coaxial with and connected to the cathode terminal, a filament in the envelope coaxial with the cathode terminal and projecting into the cathode cylinder for heating said cylinder by electron bombardment, and separate terminals for the filament extending outwardly of the envelope through said cathode terminal.

5. An electron tube structure comprising an envelope having a tubular cathode terminal at one end, a cathode in the envelope comprising a cylinder including thoria and tungsten sheet coaxial with said terminal, a cathode supporting sleeve between said cathode cylinder and the terminal, a filament in the envelope and projecting into the cathode cylinder for heating said cylinder by electron bombardment, a stem supported in the cathode terminal, and conductor rods projecting from said stem for supporting the filament.

6. An electron tube structure comprising an envelope, a cathode in the envelope comprising a cylinder including thoria and tungsten sheet, a helical filament of unthoriated tungsten within the cathode cylinder, a tungsten center rod projecting upwardly in the cathode cylinder supporting the upper end of the filament, and carbon disks on the center rod extending transversely of the cathode adjacent the upper and lower ends of said cathode cylinder.

7. An electron tube structure comprising an envelope, a cathode in the envelope comprising

a cylinder including thoria and tungsten sheet, a helical filament within the cathode cylinder, a tungsten center rod projecting upwardly in the cathode cylinder supporting the upper end of the filament, a tungsten cap on the upper end of the cylinder, an apertured tungsten disk on the lower end of the cylinder, and a carbon disk on the center rod adjacent said apertured disk.

8. An electron tube structure comprising an envelope, a cathode in the envelope comprising a cylinder including thoria and tungsten sheet, a helical filament within the cathode cylinder, a tungsten center rod projecting upwardly in the cathode cylinder supporting the upper end of the filament, a tungsten cap on the upper end of the cylinder, an apertured tungsten disk on the lower end of the cylinder, a carbon disk on the center rod adjacent said apertured disk, and a second carbon disk on the top of the center rod between the filament and said cap.

9. An electron tube comprising an envelope having a tubular cathode terminal at one end, a grid terminal ring interposed in the envelope wall between the cathode terminal and the other end of the envelope, a cylindrical grid in the envelope connected to said grid terminal, a cathode in the envelope comprising a cylinder connected to the cathode terminal, said grid and cathode cylinder being coaxial with the cathode terminal, a cathode heating filament in the envelope and projecting into the cathode cylinder, and separate terminals for the filament supported by the cathode terminal, the filament terminals and said grid terminal being coaxial with the cathode terminal.

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