March 24, 1959 V. J. DE SANTIS ET AL 2,879,429

HIGH POWER ELECTRON TUBE

Filed March 19, 1956

FIG.1

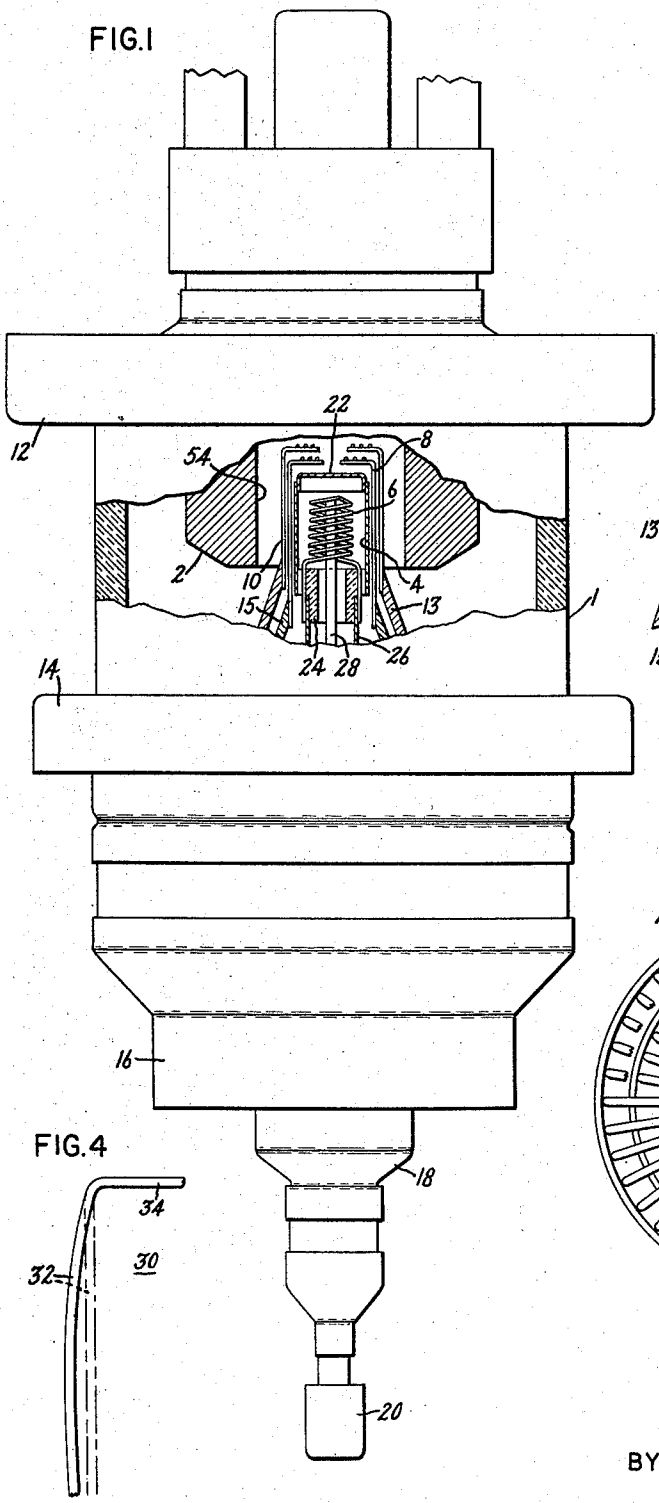


FIG.2

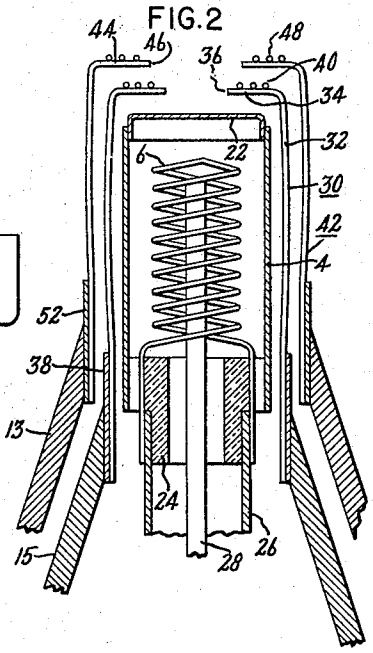


FIG.3

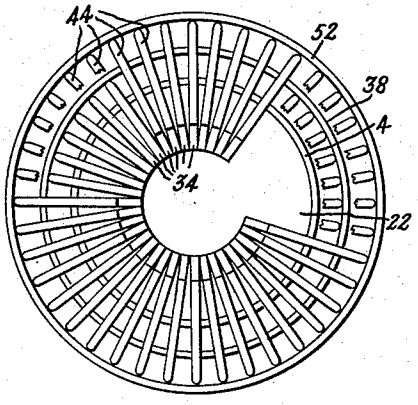


FIG.4

INVENTORS:
VINCENT J. DE SANTIS,
MARION J. SLIVKA,
BY Nathan Lowfield
THEIR ATTORNEY.

United States Patent Office 2,879,429
Patented Mar. 24, 1959

2,879,429

HIGH POWER ELECTRON TUBE

Vincent J. De Santis and Marion J. Slivka, Schenectady, N.Y., assignors to General Electric Company, a corporation of New York

Application March 19, 1956, Serial No. 572,257

5 Claims. (Cl. 313—293)

This invention relates to improvements in electrode elements for high power electron tubes, and more particularly to an improved cathode-grid assembly particularly suitable for use in high frequency, high power electron tubes.

It is recognized in the art that the overall performance of high frequency, high power, grid-controlled tubes is principally limited by deficiencies in the properties of the cathode and grid or grids. This is made evident by the fact that the two principal modes of failure of such tubes are shortened cathode life, and distortion of the grids resulting in electrical shorting of a grid to the cathode or one grid to another. The factors contributing to shortened cathode life are particularly intensified under the conditions of elevated temperature and high emission repetition rate inherent with high frequency-high power tube operation. Also the high temperatures resulting from the high heat dissipation inherent at high powers, together with the small grid-to-cathode and grid-to-grid spacing required for high frequency operation, intensify the problem of thermal buckling of the grids and consequent grid-to-grid or grid-to-cathode shorting.

Accordingly, one object of the present invention is to provide an electron tube cathode-grid assembly which has an increased capacity for withstanding the conditions encountered in high frequency, high power tube operation.

Another object is to provide an improved cathode-grid assembly for an electron tube consisting of a cathode of abundant emissive capacity and prolonged life, and a grid of improved mechanical stability under the conditions of temperature developed during high power, high frequency tube operation.

Another object is to provide in a grid-controlled high power electron tube an improved cathode-grid combination which has superior mechanical strength and resistance to deformation at high temperature, and which is particularly adapted for performance under the conditions of extremely close grid-to-cathode and/or grid-to-grid spacing required for high operating frequencies.

These and other objects of the invention will be apparent from the following description, and the scope of the invention will be defined in the appended claims.

Briefly, the invention consists of a cathode-grid assembly comprising a thorium-activated cathode made up of thoriated emissive material in sheet-like form wrought from pre-mixed and sintered powdered tungsten and thoria, and a grid consisting of a member or members each having a supporting tungsten core covered or coated with a noble metal, preferably platinum.

In the drawing—

Figure 1 is an elevational view, partly broken away to show, in axial section, one form of electron tube having a grid-cathode assembly constructed in accordance with the present invention;

Figure 2 is an enlarged axial sectional view of the cathode-grid portion of the tube shown in Figure 1;

Figure 3 is an enlarged top view, partly broken away, of the structure of Figure 2; and

Figure 4 is an enlarged exaggerated view of a portion of one element of a grid of the tube of Figure 1.

Referring now to the drawing, and particularly to Figure 1 thereof, the present invention is shown embodied in a high power high frequency electron tube particularly suitable for use, for example, in transmitter applications in the ultra high frequency range. The tube shown is of the tetrode type and includes an envelope **1** made of alternate members of insulating and conducting material, and electrodes consisting of an anode **2** which may be gas or liquid cooled, an indirectly heated cathode **4**, a heater **6**, a control grid **8**, and a screen grid **10**. All of the electrode elements are provided with suitable external electrical connections, the anode being connected to an annular anode terminal **12**, the screen grid being connected by a conical support **13** to a screen grid terminal **14**, the control grid being connected by a conical support **15** to a control grid terminal **16**, the cathode to a cathode terminal **18**, and the heater to a heater terminal **20**. The remaining details of a tube of this type form no part of the present invention, and a detailed description thereof may be found, for example, in the copending application of Robert E. Manfredi, filed March 8, 1952, S.N. 275,522, assigned to the assignee hereof.

The cathode **4** consists of a hollow cylinder or tube made up of sheet material rolled into cylindrical shape. One end of the cylinder is closed by a cup-shaped heat shield **22** and the ends of the heater **6** are brought out through a bushing **24** at the other end of the cathode. The lower end of bushing **24** is received within a cathode support tube **26** which serves as one heater lead, the other heater lead being provided by a central heater supporting rod **28**.

For optimum emission efficiency, the emission surface of the cathode is preferably carburized, for example by heating in an atmosphere containing carbon, such as a hydrocarbon atmosphere, or by coating the surface of the cathode with carbonaceous material and subsequently heat treating.

The control grid **8** is concentrically disposed about the cathode in closely spaced relation therewith, and consists of a basket-like structure including a plurality of L-shaped wires **30**, Figure 2. The long arms **32** of the wires are arranged substantially parallel to and in equally spaced circumferential relation about the axis of the cathode **4**, and the short arms **34** of the wires are arranged radially with respect to the axis of the cathode in a plane perpendicular to the cathode axis and closely spaced to the heat shield **22**. The long arms **32** are barreled outwardly lightly; as shown in exaggerated fashion in Figure 3, so that upon expansion during heating they will deflect away from, rather than toward, the cathode and hence preclude any contact with the cathode. The short arms **34** of the wires are of such a length that their free ends are slightly spaced and thus leave a small central opening **36** opposite the center of the heat shield. The free ends of the long arms of the control grid wires are joined by a conductive collar **38** welded thereto which is in turn electrically and mechanically connected to the conical support **15**. The short arms of the grid wires are mechanically and electrically connected by a few turns of similar wire **40** coiled thereon and welded thereto.

The screen grid is of a construction practically identical to the control grid and consists of L-shaped wires **42** equal in number to the L-shaped wires **30** of the control grid and positioned in the respective electron shadows of the control grid wires. That is, each screen grid wire **42** is positioned in the same radial plane through the axis of the cathode as a corresponding control grid wire **30**. The free ends of the short arms **44** of the screen grid

wires are spaced slightly farther apart than the ends of the short arms of the control grid wires so as to form an opening **46** slightly larger than and opposite to opening **36**. The short arms of the screen grid wires are mechanically and electrically connected by a few turns **48** of similar wire welded thereto, and the free ends of the long arms **50** of wires **42** are mechanically and electrically connected by a collar **52** welded thereto and in turn connected to support **13**.

The anode or plate **2** consists of a relatively large mass of good thermal conductivity such as copper, which may be gas or liquid cooled. The plate is shaped and arranged so as to have an electron receiving surface **54** of cylindrical shape concentrically arranged with respect to the cathode and grids. The anode surface **54** is very close to the screen grid, and the spacing of the screen to the control grid and control grid to the cathode is likewise made correspondingly small in accordance with the requirements of tube operation at high frequencies.

In accordance with the invention, the cathode sheet material is wrought from pre-mixed and sintered powdered tungsten and thoria and is of such a nature that the thoria is finely divided and uniformly distributed in the grain boundary regions or intercrystalline spaces of the tungsten, preferably in the ratio of up to four percent by weight. An electron emitter consisting of such material is described in detail in the copending application of M. J. Slivka, Serial No. 572,137, filed March 16, 1956, and assigned to the assignee hereof. It will be understood from the foregoing and the disclosure of the mentioned copending Slivka application that the term "wrought" is not herein used in its general sense in which it simply means, for example, "fashioned" or "formed" but, instead, is used in its metal-working sense wherein it means "work hardened, hammered or beaten into shape by tools to improve the mechanical characteristics of the material."

The advantages of a cathode constructed in accordance with the invention are several. First the sheet-like form of the cathode inherently provides excellent mechanical strength and hence good dimensional stability and freedom from deformation under severe high temperature operating conditions. By the term "sheet-like" is meant any configuration which may be generated by the path through space of a line, either straight or curved, and thereby including not only a cylinder but a flat plane, curved plane, cone, sphere and the like, as opposed to wires, rods or the like. Also from the standpoint of abundance of emission and long emissive life the cathode is capable of superior performance. This is due principally to the relatively small grain size of the tungsten, e.g., of the order of fifteen thousand grains per square millimeter, and the exceptional uniformity of distribution of the thoria in the grain boundary regions between the tungsten crystals which results from fabrication of the cathode from pre-mixed and sintered powdered tungsten and thoria. A cathode so fabricated has the advantage that the thoria therein, being locked or stored in uniformly distributed relation in the interstices between the tungsten grains, is afforded optimum protection or shielding from dissociation by deleterious external forces such as bombardment of the cathode by external electrons. The thoria beneath the surface of the cathode is thus conserved until needed, yet thorium atoms are free to migrate to the surface of the emitter through the many avenues formed by the interstices between the small tungsten grains, as necessary to replenish the monolayer of thorium at the cathode surface from which the electrons are actually emitted. Thus, from an electrical standpoint, the cathode has the inherent capacity for both abundant emission and long life, while its sheet-like form provides from a mechanical standpoint the desirable attributes of relatively easy fabrication and high strength.

While providing the advantages above mentioned, a

cathode of the character described aggravates the problem of thermal deformation of the grids, however. This is because such a cathode requires more heater power for efficient emission in comparison, for example, to a cathode merely coated with thoria, and because, having a surface which is metallic in nature, as opposed for example to the non-metallic nature of the surface of a thoria coated cathode, it radiates more heat to the adjacent grids. Also the metallic surface of the cathode affords no electrical insulative protection from a short circuit should there be a momentary contact between grid and cathode, and hence with a cathode of this type no contact between grid and cathode can ever be tolerated. As a practical matter, in fact, it has been found that a grid heretofore satisfactory with conventional cathodes, such as for example a grid made of platinum clad molybdenum wire, is incapable of performing satisfactorily and without thermal buckling at the levels of frequency and power now possible with a cathode of the character described.

Further in accordance with the present invention, therefore, the grids are constructed of material consisting of a tungsten core covered or jacketed with a noble metal. Preferably the noble metal is platinum, clad onto the core in the proportion of 20 to 30 percent by weight. Optionally, however, the cladding metal may consist of other metals of the noble metal class, e.g. ruthenium, paladium, rhodium, osmium, iridium, etc., and applied to the tungsten core by various other coating methods such as spraying, plating, etc. To increase the hot strength of the grid material and optimize mechanical and dimensional stability, the individual pieces thereof are cut from stock which has been heat treated to provide stress relief and eliminate mechanical deformities. The resulting superior hot strength of the platinum covered tungsten enables full advantage to be taken of the higher operating frequency and power levels obtainable with the improved cathode. This combination is particularly advantageous where the grid or grids are such a structural nature, as illustrated in the drawing, as to be inherently relatively frail and thus highly susceptible to thermal buckling or mechanical shock.

Thus, the improved grid-cathode combination according to the present invention enables the attainment of dependable long life performance under the conditions of extremely close grid-to-cathode and grid-to-grid spacing required for high frequency operation, while effectively eliminating the problem of grid to grid or grid to cathode shorting, thereby insuring prolonged dependable tube operating life at new high levels of operating frequency and power.

It will be appreciated by those skilled in the art that while a specific embodiment of the invention has been shown and described, the invention may be carried out in various ways and may take various forms other than the illustrative embodiment heretofore described without departing from the principles of the invention. It is to be understood, therefore, that the scope of the invention is not limited by the details of the foregoing description but will be defined in the following claims.

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

1. In a high frequency, high power electron tube, the combination of a grid having a tungsten core covered with a noble metal and an indirectly heated cathode consisting of a sheet metal member of wrought sintered powdered tungsten and thoria in closely spaced relation with said grid.

2. In a high frequency, high power electron tube, the combination of a grid of tungsten wire covered with only platinum and an indirectly heated cathode comprising a member of sheet metal consisting of a wrought sintered mixture of powdered tungsten and thoria.

3. In a high frequency, high power electron tube, a hollow cylindrical indirectly heated sheet metal cathode consisting of a wrought sintered mixture of powdered

tungsten and thoria in which the thoria is uniformly distributed in the intercrystalline regions of a tungsten matrix, and a grid including a plurality of tungsten wires clad with platinum in the ratio of from 20 to 30 percent by weight and concentrically disposed in equally and closely spaced relation about the cathode.

4. In a high frequency, high power electron tube, a hollow cylindrical indirectly heated sheet metal cathode consisting of a wrought sintered mixture of powdered tungsten and thoria in which the thoria is uniformly distributed in the intercrystalline regions of a tungsten matrix, a first grid including a plurality of noble metal covered tungsten wires concentrically disposed in equally spaced relation about the cathode, and a second grid consisting of a like number of noble metal covered tungsten wires concentrically disposed in equally spaced relation about the first grid with the wires of the second grid in common radial planes with the wires of the first grid.

5. In a high frequency, high power electron tube, a hollow cylindrical indirectly heated sheet metal cathode

consisting of a wrought sintered mixture of powdered tungsten and thoria in which the thoria is uniformly distributed in the intercrystalline regions of a tungsten matrix, a first grid including a plurality of platinum clad tungsten wires concentrically disposed in equally spaced relation about the cathode, and a second grid consisting of a like number of platinum clad tungsten wires concentrically disposed in equally spaced relation about the first grid with the wires of the second grid in common radial planes with the wires of the first grid.

References Cited in the file of this patent

UNITED STATES PATENTS

1,700,454	Schumacher	Jan. 29, 1929
2,389,060	Kurtz	Nov. 13, 1945
2,417,459	Eitel et al.	Mar. 18, 1947
2,459,792	Chevigny	Jan. 25, 1949
2,524,001	Spencer	Sept. 26, 1950
2,539,096	Miller	Jan. 23, 1951
2,749,469	Shrader	June 5, 1956