March 25, 1958 | H. J. DAILEY | 2,828,437

LOW INDUCTANCE CATHODE AND TUBE STRUCTURE

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Fig. I.

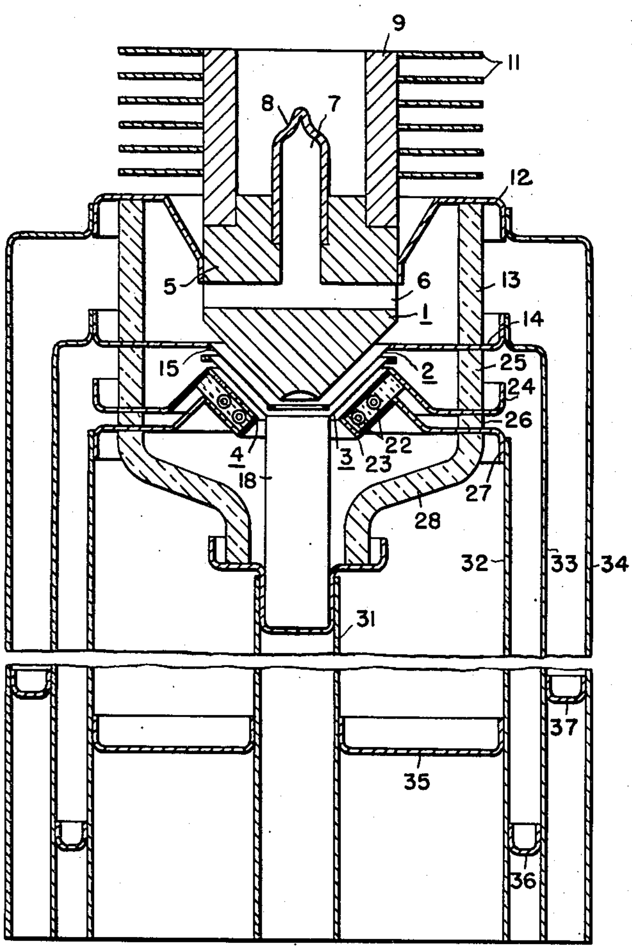

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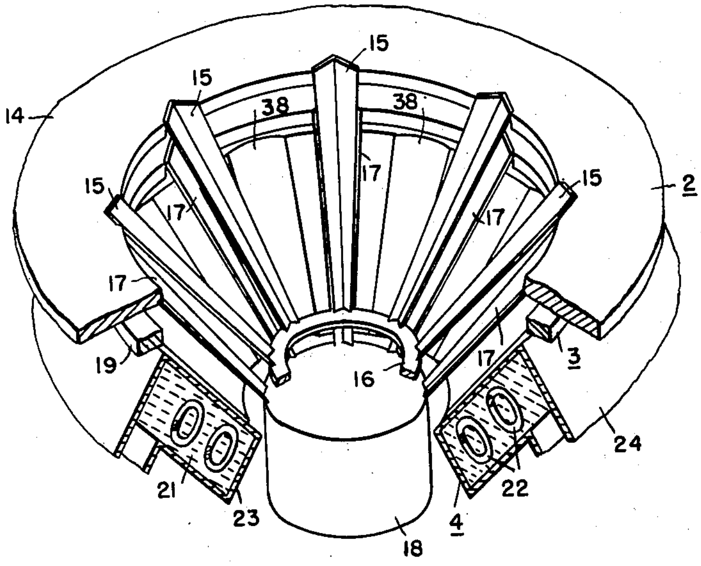
Fig. 2.



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United States Patent Office

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LOW INDUCTANCE CATHODE AND TUBE STRUCTURE

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Application July 10, 1952, Serial No. 298,164

8 Claims. (Cl. 313—249)

My invention relates to grid controlled electron tubes and in particular relates to tubes of a type intended for use at ultra-high frequencies; e. g. frequencies of the order of five hundred megacycles or more.

Electron tubes for use at such high frequencies are subject to a number of limitations which make their design extremely difficult. For instance the spacings between their electrodes must be kept down to minimize the transit time of electrons in passing from cathode to anode; the length of the electrodes must be limited to a small fraction of a wave-length at the operating frequency to minimize self-inductance in the circuits and voltage variation between different points along the electrodes; and capacitances between electrodes must be kept as low as possible. Tubes of conventional design meeting these conditions would have to be of very small dimensions, and consequently their ability to dissipate the power losses incident to any tube operation limits the useful power that can be obtained from them to a small value. Thus, the so-called "lighthouse" type tube widely used for ultrahigh frequencies during and since the recent war is limited to around ten watts output power. It has a disc cathode of about one-quarter inch diameter with other elements having dimensions of similar order. Higher power could be attained by increasing current, for instance by increasing cathode area, but if the attempt were made to do this by simply building a "lighthouse" type tube to larger scale the above-mentioned difficulties set in and made it impossible to operate the tube satisfactorily at the high frequencies desired. Hence the problem arises of increasing cathode area without increasing length along the cathode, while still maintaining electrode spacings within the necessary limits.

One object of my invention is accordingly to provide a new and improved type of electron tube for ultra-high frequency service.

Another object is to provide an ultra-high frequency tube of greater power output than present tubes operating at the same frequency.

Still another object is to provide a radio tube of novel design in which the electrodes are of such form as to have high rigidity and minimum tendency to distortion by reason of heating or of electric fields.

Yet another object is to provide an electron tube in which the current in-leads to the various electrodes are so positioned as to minimize difficulties from inter-circuit capacitance.

Still another object is to provide a grid-controlled electron tube particularly adapted for grounded cathode operation.

Yet another object is to provide a grid-controlled electron tube capable of operation at ultra-high frequencies without neutralization for the control-grid-to-cathode signal input.

Other objects of my invention will become apparent on reading the following description taken in connection with the drawings, in which:

Fig. 1 is a mid-sectional view of a tube embodying the principles of my invention; and

Fig. 2 is an isometric view to enlarged scale of the cathode, control-grid and screen-grid of the tube of Fig. 1.

Referring in detail to the drawings, the tube comprises an anode **1**, a screen grid **2**, a control grid **3** and a cathode **4**. The anode **1** is made of copper in the form of a frustum of a cone having an aperture of about 90 degrees. The upper portion **5** of the anode **1** is cylindrical and has a passage **6** going diametrically through it and connecting with an axial passage **7** in which an exhaust-pipe **8** is set vacuum tight by means of which the tube may be sealed off from the pumping system after being exhausted in accordance with usual tube-making practice. The upper end of the anode **1** is also provided with a tubular continuation **9** of good heat-conducting metal, such as copper which is provided with cooling-vanes **11** to prevent overheating of the anode in service.

The anode is supported by a vacuum-tight joint in a sheet metal annulus **12** having a surface portion capable of sealing vacuum-tight to a cylindrical glass wall-portion **13**, which is sealed at its lower end to an annulus **14**, the central opening of which is connected to the base of a conical frustum of gold-plated strip molybdenum which forms the screen grid **2** and which is described and shown in more detail in Fig. 2.

The effective portion of the screen grid **2** is made up of tapered bars **15** of gold-plated sheet molybdenum preferably creased down the middle so that they have a slightly V-shaped cross-section, these bars being equally spaced about the circumference of a conical surface and parallel to the conical surface of anode **1**. For clarity in Fig. 2 the spacings between the bars are exaggerated. The lower ends of the bars **15** are tied together by a ring **16** so that, with their upper ends welded to the annulus **14**, a rigid structure, little disturbed by vibration or temperature variation, is formed.

The control-grid **3** is likewise made up of tapered creased bars **17** of gold-plated sheet molybdenum, parallel to and directly below the bars **15** of the screen grid. The lower ends of the bars **17** are affixed to a copper centerpost **18** which is sealed through the lower end of the tube; and the upper ends of said bars are tied together by a ring **19** so that the control-grid **3** likewise has a rigid structure.

The cathode **4** comprises a frustum of a cone, the upper surface of which is parallel to the conical surface of the anode **1** and to the bars of screen-grid **2** and control-grid **3**. The cathode body comprises a refractory material **21** such as porcelain molded about a heater-wire **22** and having a jacket **23** of sheet nickel which is welded to an annulus **24**. The latter is sealed between two glass rings **25** and **26**, which are respectively sealed to the annulus **14** and to an annulus **27**. The inner edge of the latter is molded with the refractory **21**, and the cathode heater-wire **22** which is preferably wound non-inductively, is connected between the annuli **24** and **27**. The lower face of annulus **27** is sealed to the upper edge of a glass wall-portion **28** which has its lower edge sealed to a thimble which terminates the center-post **18**.

The inner surface of the cathode is provided with concave troughs **38** which are surfaced with thermionically emissive material such as barium-strontium oxides. The troughs **38** are elements of the conical surface and have azimuths positioned midway between those of the bars **15** and **17** of the screen-grid **2** and control-grid **3**. The concave surface of the emitting oxides tends to focus the emitted electrons into streams which bypass the bars of these grids and impinge only on the anode **1**. Thus grid-currents are minimized in this tube.

To give an example of practicable dimensions for this tube the spacing between the conical electrode surfaces may be 0.015 to 0.020 inch.

The flow of high frequency currents both to the cathode and the two grids is radial in direction, and it is the radial dimension of these electrodes, in the region of electron-current flow between cathode and anode, which governs the operation of the tube. This radial dimension is made comparatively small, even though the total area is large, by adopting the annular configuration for the cathode and keeping the radial dimension along the conical surface small relative to wavelength; e. g. not over one-fifth of said wavelength. The conical form minimizes distortion of the structure and thermal expansion during operation does not materially affect interelectrode spacings. The aperture angle of the cone used here has been about 90 degrees but it should be recognized that other aperture angles are within the purview of my invention, and that the increase of cathode area while maintaining the effective radial dimension low results from the annular form with its central opening, and is present even in a cathode made in washer-form; i. e., in a frustum of a cone with an aperture of 180 degrees.

It will also be noted that the screen-grid and cathode terminals **14** and **24** are adjacent so that this grid and cathode may be effectively maintained at the same radio frequency potential by connecting them to the two sides of a concentric conductor or other distributed-constant line effectively short circuited at a point half a wavelength distant. This would permit use of this tube as an ultra-high frequency amplifier without neutralization for the control-grid to cathode circuit; i. e., would permit so-called "grounded cathode operation."

While I have described my invention as embodied in a tube having two control grids, its advantages in obtaining large cathode area with small length in the direction of current flow, rigidity of structure and invariability of electrode springs during temperature variation are equally attainable in tubes where only one conical grid, or three or more such grids, are employed.

Concentric-line tuners for the electrode circuits may conveniently be formed as in Fig. 1 by providing tubular extensions, **31** for the control grid, **32** for the cathode annulus **27**, **33** for the screen grid annulus and **34** for the anode annulus **12**. Sliding piston **35** may be provided to interconnect the control grid and cathode at a quarter-wave length distance. Sliding piston **36** interconnects the cathode and screen grid, as stated above, at a half-wave length distance. Sliding piston **37** interconnects the screen grid and anode at a quarter-wave displacement when desired.

I claim as my invention:

1. An ultra-high frequency electron tube for operating between frequencies of from 500 to 3000 megacycles comprising a vacuum-tight container, an anode, a cathode having an electron-emitting surface which surrounds a central opening in said cathode, said cathode and said anode having substantially parallel frusto-conical surfaces, the radial dimension of said electron-emitting surface being not over one-fifth of the wavelength of said frequency, and a control-electrode between said anode and said surface, said control electrode being parallel to said anode and said electron emitting surface.

2. An ultra-high frequency electron tube comprising a vacuum-tight container, an anode, a cathode having an electron-emitting surface which surrounds a central opening in said cathode, and a plurality of auxiliary electrodes between said anode and said electron emitting surface, said cathode, said anode and said auxiliary electrodes having substantially parallel frusto-conical surfaces at least one of said auxiliary electrodes having an in-lead which passes through said central opening.

3. An electrical discharge tube comprising a vacuum-tight container, an anode, a cathode having an electron-emitting surface in the form of a conical frustum, and a control electrode having a surface surrounding a central opening in said control electrode concentric with said frustum, said electron-emitting surface comprising fluted portions concave toward said anode.

4. An electrical discharge device comprising a vacuum-tight container, an anode, a cathode having an electron-emitting surface in the form of a conical frustum, and a control electrode comprising metallic bar members having a V-shaped cross section, said bar members being parallel to said electron-emitting surface.

5. An electrical discharge tube for operating between frequencies of from 500 to 3000 megacycles comprising a vacuum-tight container, an anode having a conical surface, a cathode having an electron-emitting surface having the form of a conical frustum, and an auxiliary electrode having the form of a perforated surface of a conical frustum, all of said surfaces being parallel and said cathode having no dimension on lines radiating from the conical apex which exceeds one-fifth of the wave length of said frequency.

6. An electrical discharge tube comprising a vacuum-tight container, an anode having a conical surface, a cathode having a surface in the form of a conical frustum concentric to said conical surface, said cathode having an electron emitting surface which surrounds a central opening in said cathode, and a control electrode between said anode and said cathode, said control electrode being parallel to said anode and said cathode and having a frusto-conical configuration.

7. An electrical discharge tube comprising a vacuum-tight container, an anode having a conical surface, a cathode having a surface in the form of a conical frustum, and an auxiliary electrode comprising metallic bar members, said metallic bar members being parallel to elements of said conical surface.

8. An electrical discharge tube having a vacuum-tight container comprising cylindrical glass wall-portions sealed to opposite sides of annular plates, a frusto-conical cathode having an electron-emitting surface which surrounds a central opening in said cathode supported by certain of said plates, a conical anode supported near said cathode from one end of said container, and a control electrode between said anode and cathode supported from the other end of said container, said anode and said control electrode being parallel to said cathode and said control electrode having a frusto-conical configuration.

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