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ELECTRON DISCHARGE DEVICE FOR HIGH-FREQUENCY

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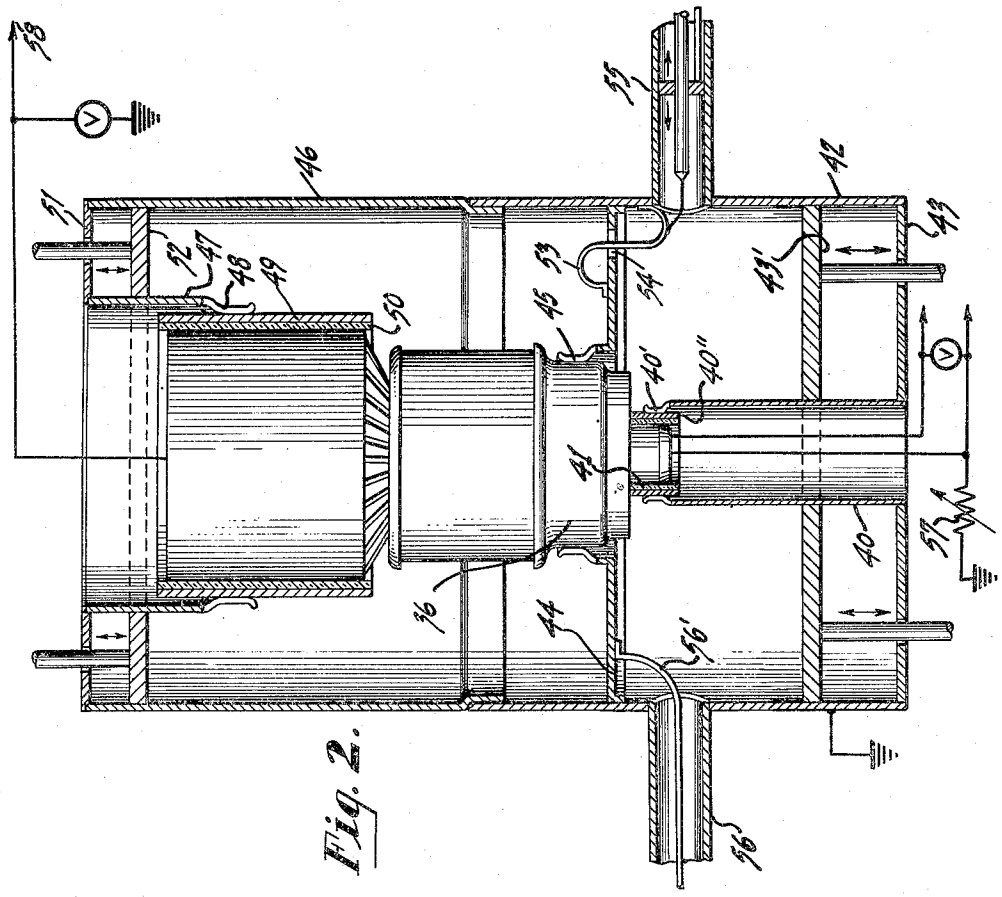


Fig. 2.

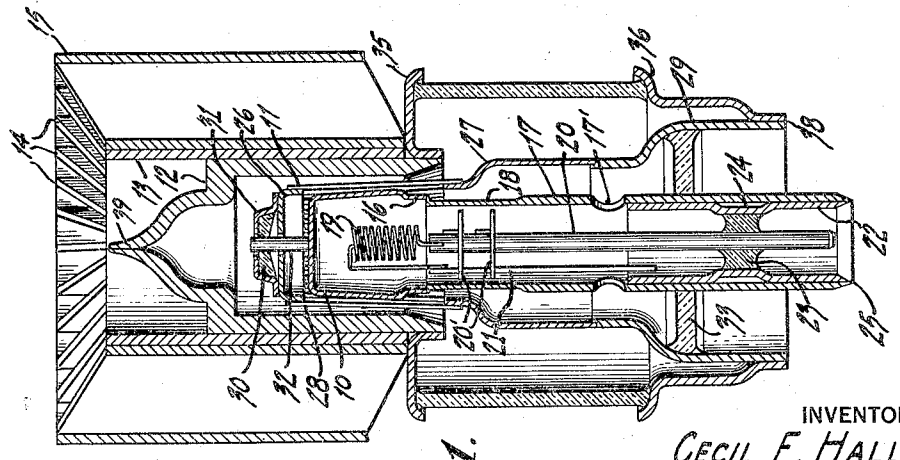


Fig. 1.

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ELECTRON DISCHARGE DEVICE FOR HIGH FREQUENCY

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My invention relates to electron discharge devices useful at ultra high frequencies and more particularly to such devices of improved design having improved characteristics and promoting ease of assembly.

In certain types of high power-high frequency tubes an inverted cup-shaped cathode is enclosed within an inverted cup-shaped grid, the grid comprising upper and lower bands or rings between which longitudinally extending wires are supported and to which they are welded. At very high frequencies the spacing between the cathode and grid vitally affects the operating characteristics of the tube since this spacing determines the transit time of the electrons between cathode and grid, the greater the spacing the greater the transit time of the electrons and hence the lower the upper frequency of operation. Since the grid wires are ordinarily welded externally to the rings, the grid-cathode spacing is limited by the thickness of the supporting rings or bands. It is, therefore, desirable to provide some means of construction whereby the thickness of the ring or band has no effect on the spacing between the grid wires and the cathode surface.

In tubes of the kind under discussion interelectrode capacities are also of importance. The close spacing, however, demanded by high frequency operation increases interelectrode capacities as well as the possibility of electrode shorts and interferes with easy assembly. It is, therefore, desirable to provide a construction permitting close spacing of the working surfaces of the electrodes which will nevertheless minimize interelectrode capacity, reduce liability of shorts and facilitate assembly of the electrode mount.

Close spacing of electrodes and their supporting structures also makes the problem of sealing the envelope, whether by flame or welding if of metal, a difficult problem. Flames increase the possibility of strains and breakage and the release of undesired gases within the tube envelope. With small spacing and a plurality of concentric leads, welding is a difficult problem.

Further, in tubes of this type the inverted cup-shaped cathode is usually supported at the end of a tubular supporting member and the heater is inserted within this tubular member and the cathode. The heater must not only be firmly and rigidly supported within the tubular member but it must be so constructed that the coils of the heater are not shorted on the inner surfaces of the cathode or the supporting sleeve.

It is, therefore, an object of my invention to provide an electron discharge device useful at

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ultra high frequencies and of improved design having improved characteristics and promoting ease of assembly.

Another object of my invention is to provide a cathode-grid construction in which the desired close spacing can be accomplished without the limitation normally found with the conventional grid construction.

Another object of my invention is to provide an electron discharge device having a cathode-grid construction minimizing interelectrode capacities, the liability of interelectrode shorts and which will facilitate electrode assembly.

It is another object of my invention to provide an electron discharge device having such construction that successful seals are facilitated.

A still further object of my invention is to provide an improved indirectly heated cathode and cathode heater construction which provides a sturdy and rigid support for the cathode heater and in which the liability of cathode heater shorts is reduced.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a longitudinal section of an electron discharge device made according to my invention and Figure 2 shows an electron discharge device made according to my invention and shown in Figure 1 utilized in a cavity resonator circuit.

Referring to Figure 1, an electron discharge device made according to my invention comprises an inverted cup-shaped cathode 10 of tapering shape surrounded by a grid 11 and an inverted cup-shaped one-piece anode 12 all nested to provide a triode assembly. The anode may be provided with a sleeve 13 to which the radiator comprising an outer collar 15 and radially directed fins 14 are secured. The tapered cathode is provided with a collar 16 of reduced diameter supported on a tubular member 17 having a portion 18 of reduced thickness for reducing heat conduction between the cathode proper and the cathode support. A cathode heater 19 comprising a coil welded at its lower end to the coaxial rod 20 has a lead 21 extending from its upper end and secured to the tubular member 22. Member 22 has the reduced portion 24 and the hermetic seal 23 extends between the reduced portion 24 and the supporting rod 20. The lower end of the tubular member 22 is sealed to the outer tubular member 17 at its lower end by

means of high frequency welding. An opening 17' may be provided for degassing purposes.

The grid is provided with an inverted cup-shaped cap 26 and a tubular flared-out apron member 27 between which the vertical grid wires 28 extend and are welded. The lower end of the tubular grid apron and support 27 is provided with a second flared-out apron member 29. The upper end of the cathode is provided with a pin 32 extending through and contacting only the insulator 30 for centering the upper end of the grid and the cathode, the insulator being retained by cap 31 on the cap 26. It will be observed that since the cap 26 is above the cathode and the upper portion of the tubular member 27 is below the portion 16 of reduced diameter of the cathode, that the thickness of the cap and skirt do not interfere with the close spacing between the cathode surface and the grid wires 28 of grid 11, this spacing being anything possible within manufacturing limits. Because of the constricted portion 16 of the cathode the cathode surface is moved away from the grid and the anode and thereby the total inner cathode-grid capacity and cathode-anode capacity is reduced.

The lower end of the anode is provided with outwardly extending flange 35 and the lower end of the grid skirt 29 with the collar 36 flared upwardly and outwardly. A glass collar 37 is sealed between the flange 35 and the member 36. Members 29 and 36 are radio frequency welded at the lower ends at 38 thus forming a complete envelope for the tube when the transverse seal 33 is made between tubular member 24 and the skirt 29.

The heat shields 20' supported on the conductor 20 of the cathode heater assembly reflect the heat back up into the interior of the cathode 10. Should a short occur between the lead 21 and the inner surface of the supporting sleeve 17, no shorting of the cathode heater will occur.

In assembly, the cathode and grid are assembled as a unit without the heater, the seal being made between the outer tubular member 24 and the apron 29 by means of the disc seal 33. This permits the grid and cathode to be jigged from a common center, that is the cathode sleeve, thus insuring accurate positioning. The anode 12, collar 37 and collar 36 are assembled as a unit and the cathode and grid assembly inserted within the anode assembly, the anode, grid and cathode being automatically centered when the apron 29 is received within the collar 36. Longitudinal spacing is insured by registering the ends of members 22 and 24 and radio frequency welding at 38. The cathode heater is assembled as a unit, the restricted portion 34 insuring a good seal to the support 20 by means of the seal 23. The cathode heater is then inserted into position and a radio frequency weld made at 25.

Thus an electron discharge device having extremely close cathode-grid spacing, low interelectrode capacity, and improved cathode construction and good seals without the use of fires, which would cause stresses and strains in the insulated portions of the envelope, is insured. The construction facilitates ready and accurate assembly by utilizing the construction described above.

In Figure 2 I show an electron discharge device made according to my invention utilizing a coaxial line resonator-oscillator circuit. The input circuit comprises the inner tubular member 40 having a plurality of fingers 40' at the upper end contacting a ring 40'' capacity coupled to the tubular member 17 through the insulating collar 41. An outer tubular member 42 is electrically connected to inner member 40 to form a resonator by a metallic disc-shaped end member 43. Tuning is accomplished by means of the ring 43' movable longitudinally of the resonator. The resonator is completed by means of the transverse partition member 44 having resilient fingers 45 contacting the grid collar 36. Tuning is accomplished by tuning ring 43'.

The output resonator is connected between grid and anode. The upper end of tubular member 42 is continued by means of a tubular member 46 connected with the inner tubular member 47 through conducting disc 51. Member 47 has spring fingers 48 contacting the collar 49 and are capacity coupled to the anode through insulating collar 50, preferably of mica. This resonator between anode and grid is tuned by the longitudinal moving tuning ring member 52. Thus a coaxial line capacity resonator is connected between cathode and grid and between anode and grid. The device may serve as an oscillator by providing aperture 54 in the partition 44 and utilizing a coupling loop 53 extending through the aperture and having loops within the two resonators. The load may be taken out of the grid-cathode resonator by means of the coaxial line 56 having the inner loop 56' terminating on the partition 44. The cathode heaters may be supplied from the source 57 and the anode voltage from the source 58.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device having an elongated hollow tubular cathode assembly closed at one end by an inverted cup-shaped cathode tapered inwardly toward its closed end, an elongated grid assembly positioned over said cathode assembly and coaxial therewith, said grid assembly including a cup-shaped grid tapered to conform to said cathode and positioned over said cup-shaped cathode and closely spaced therefrom, said grid assembly having a skirt-shaped conducting support of outwardly flared construction and a seal of insulating material extending between said cathode assembly and said skirt-shaped conducting support adjacent but spaced from the end of said skirt-shaped conducting support opposite said grid.

2. An electron discharge device having an elongated hollow tubular cathode assembly closed at one end by an inverted cup-shaped cathode tapered inwardly toward its closed end and having an annular emitting surface, an elongated grid assembly positioned over said cathode assembly and coaxial therewith, said grid assembly including an inverted cup-shaped tapered grid positioned over said cup-shaped cathode and closely spaced therefrom, and having a skirt-shaped conducting support and a seal of insulating material extending between said cathode assembly and said conducting support, said cup-shaped grid including a cap spaced above the end of said cathode, and longitudinally extending grid conductors extending between said cap and

one end of said conducting support, the portions of said cap and said conducting support to which said grid conductors are secured being positioned outside the projected emitting surface of said cathode whereby said grid conductors may be spaced from said emitting surface a distance less than the thickness of the walls of said cap and said skirt.

3. A heater for a hollow indirectly heated cathode, said heater including a rod-like conductor, a tubular member coaxial with and surrounding said conductor and an insulating seal extending between said conductor and said tubular member, said tubular member being constricted at said seal, a heater mounted at one end of said rod-like conductor and having one end connected to said conductor and the other end connected to said tubular member, said heater being supported solely by said rod-like conductor and said tubular member.

4. A heater for a hollow indirectly heated cathode, said heater including a rod-like conductor, a tubular member coaxial with and surrounding said conductor, and an insulating seal extending between said conductor and said tubular member, a heater mounted at one end of said rod-like conductor and having one end connected to said one end of said conductor, a second conductor connected to said tubular member, the other end of said heater being connected to said second conductor, and a heat reflecting disc extending transversely of and supported on said rod-like conductor between said heater and said tubular member.

5. A heater for a hollow indirectly heated cathode, said heater including a rod-like conductor, a tubular member coaxial with and surrounding said conductor, and an insulating seal extending between said conductor and said tubular member, a heater mounted at one end of said rod-like conductor and having one end connected to said one end of said conductor and the other end connected to said tubular member, said heater being supported solely by said rod-like conductor and said tubular member.

6. A cathode for an electron discharge device having an elongated conductor, a tubular member coaxial with and surrounding said conductor, and a vacuum-tight seal between said conductor and said tubular member, and a filament supported between said conductor and said tubular member, said filament being supported solely by said elongated conductor and said tubular member.

7. An electron discharge device having an elongated hollow tubular cathode assembly closed at one end by an inverted cup-shaped cathode tapered inwardly toward its closed end, an elongated grid assembly positioned over said cathode assembly and coaxial therewith, said grid assembly including a cup-shaped grid tapered to conform to the surface of said cathode positioned over said cup-shaped cathode and closely spaced therefrom, said grid assembly having a skirt-shaped conducting support, a disc seal of insulating material extending between said cathode and said skirt-shaped conducting support, and a heater within said cathode and comprising an inner conductor and an outer conductor surrounding said inner conductor, and a cathode filament supported on said inner conductor and connected between said inner conductor and said outer conductor, and a vacuum-tight seal extending between said inner and outer conductors adjacent the open end of said cathode.

8. An electron discharge device having an elongated hollow tubular cathode assembly closed at one end by an inverted cup-shaped cathode, an elongated grid assembly positioned over said cathode assembly and coaxial therewith, said grid assembly including an inverted cup-shaped grid positioned over said cup-shaped cathode and closely spaced therefrom, and having a skirt-shaped conducting support, a disc seal of insulating material extending between said cathode assembly and said skirt-shaped conducting support adjacent but spaced from the end of said skirt-shaped conducting support opposite said grid, and an inverted cup-shaped anode nested over said cathode and grid and an insulating collar member sealed between said anode and the skirt-shaped conducting support of said grid.

9. An electron discharge device having an elongated tubular supporting member closed at one end by a cup-shaped cathode, an inverted cup-shaped grid positioned over said cathode and a conducting supporting member comprising a flared skirt terminating in a straight tubular portion, and a seal between said conducting supporting member and said elongated tubular member, a collar having a straight tubular portion sealed to the tubular portion of said skirt supporting member and having an outwardly extending flange, an anode positioned over said cathode and grid and having a transversely extending flange and a tubular collar member of insulating material sealed between said flanges for providing an envelope for said cathode and grid.

10. An electron discharge device having an elongated tubular supporting member closed at one end by a cup-shaped cathode, a heater for said cathode including a conductor and a tubular member surrounding one end of said conductor, and a seal between said last tubular member and said conductor and a heater wire within said cup-shaped cathode connected between the conductor and said last tubular member, said last tubular member being heremetically sealed to the open end of said elongated tubular member, an inverted cup-shaped grid positioned over said cathode and a conducting supporting member comprising a flared skirt terminating in a straight tubular portion, and a seal between said straight tubular portion and said elongated tubular member, a collar having a straight tubular portion sealed to the end of the tubular portion of said skirt supporting member and having an outwardly extending flange, an anode positioned over said cathode and grid and having an outwardly extending flange and a tubular collar member of insulating material sealed between said flanges for providing an envelope for said cathode and grid.

11. An electron discharge device having an elongated hollow tubular cathode assembly closed at one end by an inverted cup-shaped cathode, an elongated grid assembly positioned over said cathode assembly and coaxial therewith, said grid assembly including an inverted cup-shaped grid positioned over said cup-shaped cathode and closely spaced therefrom and having a skirt-shaped conducting support, a disc seal of insulating material extending between said cathode assembly and said skirt-shaped conducting support, and an inverted cup-shaped anode nested over said cathode and grid, and an insulating collar member sealed between said anode and the skirt-shaped conducting support of said grid, and a heater within said cathode and comprising

an inner conductor and an outer conductor surrounding said inner conductor, and a cathode filament connected and supported between said inner conductor and said outer conductor, and a vacuum-tight seal extending between said inner and outer conductors adjacent the open end of said cathode, and a seal between the outer conductor and the tubular cathode assembly.

12. An electron discharge device having an elongated hollow tubular cathode assembly closed at one end by an inverted cup-shaped cathode, an elongated grid assembly positioned over said cathode assembly and coaxial therewith, said grid assembly including an inverted cup-shaped grid positioned over said cup-shaped cathode and closely spaced therefrom and having a skirt-shaped conducting support, a seal of insulating material extending between said cathode assembly and said skirt-shaped conducting support, and an inverted cup-shaped anode nested over said cathode and grid, and an insulating collar member sealed between said anode and the skirt-shaped conducting support of said grid, and a heater within said cathode and comprising an inner conductor and an outer tubular conductor surrounding said inner conductor, and a cathode filament connected and supported between said inner conductor and said outer conductor, and a vacuum-tight seal extending between said inner conductor and said outer tubular conductor adjacent the open end of said cathode, and a seal between the outer tubular conductor and the tubular cathode assembly, said outer tubular conductor being constricted at said seal.

13. An electron discharge device having an elongated hollow tubular cathode assembly closed at one end by an inverted cup-shaped cathode tapered inwardly towards its closed end and having an annular emitting surface, an elongated grid assembly positioned over said cathode assembly and coaxial therewith, said grid assembly including an inverted cup-shaped tapered grid positioned over said cup-shaped cathode and closely spaced therefrom and having a tubular conducting support, and a seal of insulating material extending between said cathode assembly and said conducting support, said cathode assembly having a smaller diameter below the emitting surface of said cathode whereby the spacing between said grid assembly and the restricted portion of said cathode is greater than the spacing between the emitting surface and the grid, said cup-shaped grid including a cap spaced above the ends of said cathode and longitudinally extending grid wires extending between said cap and one end of said conducting support, the portions of said cap and conducting support to which said grid conductors are attached being positioned outside the projected emitting surface of said cathode whereby said grid conductors are spaced from said emitting surface a distance less than the thickness of the walls of said cap and said skirt.

14. An electron tube comprising an envelope having a recessed anode at the upper end and a cathode stem at the lower end, said stem comprising an outer tubular member and an inner prong member, a grid terminal ring interposed in the envelope wall between the outer stem member and said anode and providing a cylindrical contact surface, the lower portions of the stem members projecting externally of the envelope and providing cylindrical contact surfaces coaxial with that of said grid terminal ring, the cylinders defined by said contact surfaces having different diameters of which the inner stem member is the smallest the outer stem member is next largest and the grid terminal ring is the largest, a cathode element extending into the anode recess and connected to one of the stem members, a heater for the cathode element connected to the stem members, and a grid disposed about the cathode element and connected to said grid terminal ring.

15. An electron tube comprising an envelope having a recessed anode at the upper end and a cathode stem at the lower end, said stem comprising an outer tubular member and an inner prong member, a grid terminal ring interposed in the envelope wall between the outer stem member and said anode and providing a cylindrical contact surface, the lower portions of the stem members projecting externally of the envelope and providing cylindrical contact surfaces coaxial with that of said grid terminal ring, the cylinders defined by said contact surfaces having different diameters of which the inner stem member is the smallest the outer stem member is next largest and the grid terminal ring is the largest, the envelope wall being joined to the tubular stem member above its cylindrical contact surface, vacuum-tight sealing means disposed between the stem members and joined to the inner prong member above its cylindrical contact surface, a cathode element extending into the anode recess and connected to one of the stem members, a heater for the cathode element connected to the stem members, and a grid disposed about the cathode element and connected to said grid terminal ring.

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