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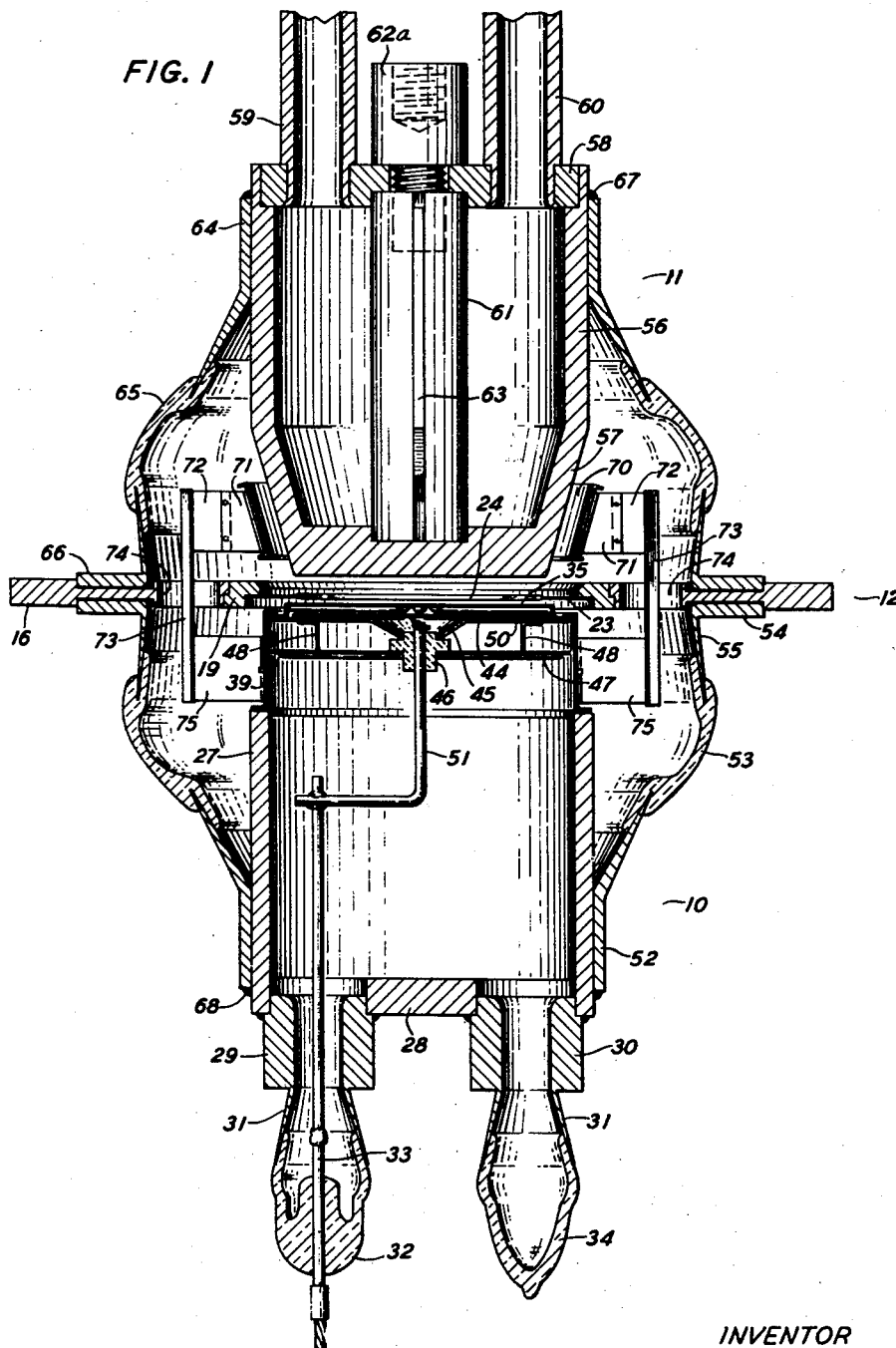
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HIGH-POWER ELECTRON DISCHARGE DEVICE

Filed Oct. 19, 1946

2 Sheets-Sheet 1



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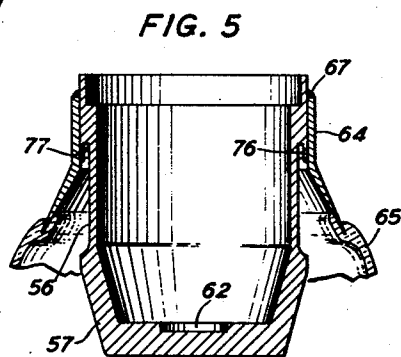
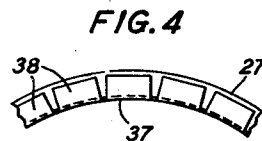
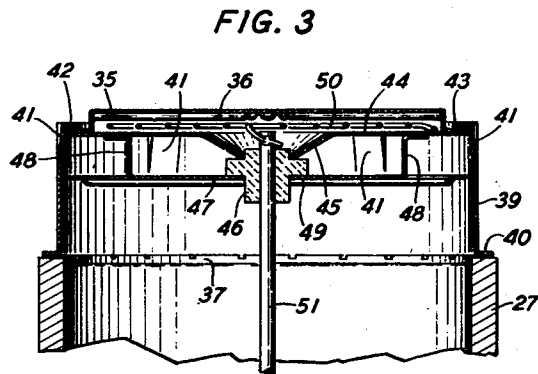
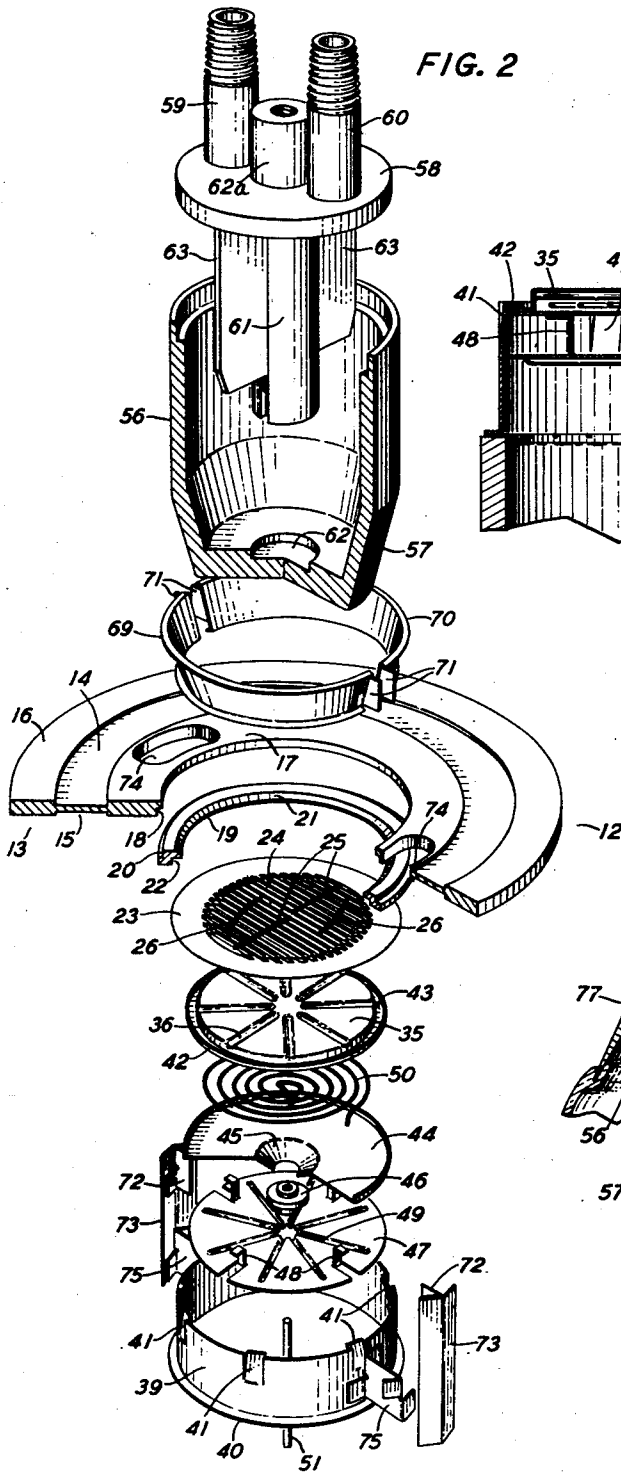
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HIGH-POWER ELECTRON DISCHARGE DEVICE

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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HIGH-POWER ELECTRON DISCHARGE
DEVICE

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14 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to such devices especially suitable for use as power generators at ultra-high frequencies.

In high frequency power transmitting systems, and particularly in such systems utilizing frequency modulation, the power generating electronic devices preferably are of the "grounded grid" type to facilitate the coupling of the devices to cooperating resonant chambers or tank circuits and coaxial lines for the efficient propagation of the energy produced in the system. In such "grounded grid" devices, the grid element or electrode may be a plane surface having a peripheral portion for direct connection in the tank circuit with the cooperating electrodes, such as an electron emitter or cathode and an output anode disposed on opposite sides of the central grid in juxtaposed planar relation. Since the output efficiency is dependent on constant interelement space relation in the device, it is highly advantageous to maintain continual stability in the space relation of the respective electrode surfaces. Realization of this condition presents considerable difficulty with the usual manufacturing processes in which vitreous portions are sealed to the grid assembly to form an hermetic joint and produce a vacuum-tight enclosure therewith.

An object of this invention is to overcome these difficulties and produce a device exhibiting constant stability during operation at ultra-high frequencies.

Another object of the invention is to insure accurate space relation of the planar electrodes in the assembly of the device.

A further object of the invention is to prevent axial expansion of the respective electrodes due to the high temperature conditions extant in the device during operation.

Another object of the invention is to reduce the time of pumping of the device during the evacuation process to complete the manufacturing assembly.

A further object of the invention is to reduce to a low value the interelectrode capacitance of the device so that energy oscillation within the discharge path is accelerated at the high operating frequency.

Another object of the invention is to neutralize the thermal impedance of the cathode assembly to avoid temperature strains or stresses being set up between the high temperature cathode and the housing supporting the same.

These objects are attained in accordance with

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features of the invention in a power generating device in which the grid or control electrode forms a medial partition through the central plane of the enclosing vessel and the cathode and anode surfaces are located on opposite sides of the grid surface to provide large parallel surfaces in accurate space relation. The electrode spacings are very small to reduce the transit time of the electrons in the discharge space. This construction enables generation of large amounts of power and the attainment of high efficiency at high frequencies over wide frequency bands.

A feature of this assembly relates to the micro-accuracy of the space relation between the electrodes to insure constant stability in the functional operation of the device. This is accomplished by utilizing the plane grid assembly as a base or foundation for the mounting of the cathode and anode assemblies in collateral relation to the active area of the grid and combining the whole assembly to form an hermetically sealed chamber or receptacle for the efficient generation of power output. The anode and cathode assemblies or sections are separately constructed to insure accurate space relation of the electrodes with respect to their peripheral mounting portion or sections and these portions are sealed to prescribed opposite surfaces of the grid flange to form an integrated enclosing vessel to which the large surface electrodes are positively held to close limits of spacing, whereby the prescribed operating characteristics of the device are maintained throughout the functional life of the device.

Another feature relates to the assembly of the cathode housing to insure a large surface area for supplying a copious source of electrons, so constructed that it will withstand the rigors of operation without buckling or changing the initial space relation relative to the grid surface. This is accomplished by providing a large area plane cathode surface, reinforced against buckling, as the electron emission source, which is coupled to a sleeve support having means to compensate for radial expansion and contraction under the high temperatures of operation but which eliminates axial elongation so that the spaced relation with the grid surface is held constant. The large cathode surface, which is heated to emission temperature, is also protected against rapid heat radiation by a supporting assembly of high thermal impedance to maintain the temperature of the cathode uniform under operating conditions. The anode is water-cooled to dissipate heat energy generated in the operation of the device and is so constructed that the output of the

device may be supplied to a coaxial line directly coupled to the anode end of the device. A similar coupling can also be connected to the cathode end of the device to provide a symmetrical and high efficiency structure for the propagation of the high frequency wave energy.

A further feature of the invention relates to reduction of the interelement capacitance to more readily neutralize the internal output impedance between the electrodes so that oscillation of the electrons is engendered to increase the generation of wave energy of high amplitude. This involves the coupling of a capacitive element between the anode and cathode in the form of a ring shield surrounding and spaced from the anode by radiator arms extending from the cathode assembly through openings in the grid flange.

Another feature relates to the construction of the grid electrode to provide rigidity in the active controlling portion and adequate support in the flange portion to insure uniform spacial relation with respect to the cathode and anode surfaces. This is realized by forming the grid surface of a highly refractory sheet metal disc which is slotted to provide edgewise directed laterals for the passage of the electron stream to the anode. The laterals are prevented from distorting by heating effects during operation, by transverse restraining or bracing wires engaging the laterals. The disc is secured to a mounting ring of similar material which is seated in the main grid flange ring sealed to the anode and cathode assemblies.

Another feature of the integrated structure of the device is the utilization of copper as the large masses of the electrode assemblies to take advantage of the low resistance characteristics of this metal to overcome objectionable heating and inductive effects when employed as components in ultra-high frequency operation. Furthermore, the "skin effect" flow of high frequency current is advantageously realized by the low resistance and reactance of the masses of the electrodes.

These and other features and advantages of the invention will be understood from the following detailed description when taken in connection with the accompanying drawings, in which:

Fig. 1 is an elevational view in cross-section of a device illustrative of this invention showing the various components entering into the assembly of the device;

Fig. 2 is a perspective exploded view of the electrodes and the component parts entering into their assembly;

Fig. 3 is an enlarged cross-sectional view of the cathode assembly and a portion of the supporting structure as employed in the device of Fig. 1;

Fig. 4 illustrates in plan view a segment of the cathode supporting structure showing the slotted flanged ring on the upper edge of the cathode housing; and

Fig. 5 is a cross-sectional view of a modified supporting assembly for the anode structure.

Referring to the drawings and particularly to Fig. 1, the high frequency electronic discharge device illustrated is particularly suitable for use as a power generator of the "grounded grid" type exhibiting low mutual transconductance and low interelectrode capacitance characteristics in order to attain high efficiency in the power output of the device. The construction of the device is characterized by three section electrode assemblies which are combined into an

integrated unit forming cooperating planar electrode surfaces enclosed in an evacuated discharge space in which the electrodes are maintained in constant relationship to insure high efficiency operation in output energy. The assembly includes as main components, a cathode housing 10, an anode housing 11, and an intermediate partition grid electrode 12, the latter forming a foundation or base for the mounting of the cathode and anode in cooperating functional relation.

The foundation electrode or grid is formed of an annular metallic disc or heavy ring shown clearly in Fig. 2 of large diameter and preferably of copper, which is provided with annular undercut medial lands 14 and 15 on opposite coextensive surfaces between an external rim 16 and an internal support portion 17. The inner edge of the ring is provided with an annular groove 18 on the lower surface to form a flush seat for a grid supporting ring 19. The ring 19 is advantageously formed of molybdenum and has an outer cooperating groove 20 on the upper surface to fit the groove 18 and an inner beveled edge 21 with an annular groove 22 on the inner lower surface to form a seat for the grid electrode blank 23. This electrode blank is formed of sheet molybdenum of a suitable diameter to fit the grooved seat 22 and the grid proper is formed by cutting parallel slots in the disc 23 and bending the slats 24 formed by the slots in parallel perpendicular relation with respect to the uncut rim of the disc. The slats 24 form rigid grid laterals which control the flow of electrons between the cathode and anode across the short gap or discharge space between the main input and output electrodes. The slats or laterals 24, lying in parallel edgewise relation, offer the least axial hindrance to the flow of electrons since the edges of the laterals are facing the electron source but the parallel side surfaces of the slats form guiding and controlling passageways for the electrons directed toward the anode. In order to prevent buckling of the slats, a pair of diametrical bracing wires 25, preferably of tungsten, extend across the transverse dimension of the slats at the center, each wire being attached to half the laterals on the respective side of the center and neither wire being connected to the same slats at the center. A pair of arcuate bracing wires 26 are disposed on diagonally opposite quadrants of the laterals in cooperation with the straight bracing wires to prevent axial and transverse shifting of the laterals under the temperature conditions extant during operation of the device. The wires preferably are welded to the laterals and the grid disc 23 is brazed in the ring 19 by high melting point solder in a hydrogen fed oven at a temperature of 1075° C. for fifteen minutes duration. The grid 23 and frame 19 are assembled as a unit in the foundation ring by brazing the interlocking grooved joints with high melting point solder to rigidly fix the grid electrode in the partition wall, so that the transverse slats or laterals 24 span the central area of the partition and the grid disc 23 lies in a plane at the mid-point of the thickness of the partition ring.

The cathode assembly and the housing therefor is shown in cooperating relation with the grid partition wall in Fig. 1 and the components of this assembly are shown more clearly in Figs. 2, 3 and 4. The cathode assembly proper includes a large diameter metallic cylinder 27, preferably of heavy copper, closed at the outer end by a

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copper disc 28 having a pair of openings to receive tubular plugs 29 and 30. The cover and plugs are sweated or brazed into the outer end of the sleeve 27 by a solder having a composition of 40 per cent silver and 60 per cent copper with a melting point of 910° C. Each of the plugs is provided with a thin-walled, knife-edge extension 31, the extension of plug 29 being terminated by a vitreous seal 32, such as hard glass, for supporting a lead-in conductor 33. The extension of plug 30 is terminated by a vitreous nipple 34 which is finally sealed after the complete assembly is evacuated and heat treated to secure a low vacuum in the enclosure for the conduction of a pure electron discharge therein.

The inner end of the tubular cathode member 27 is closed by the active emitting surface of the cathode or emitter in the form of a chemically pure nickel alloy disc 35 having a plurality of corrugations 36 stamped in the surface and radiating outwardly toward the edge to reinforce the large surface of the cathode. This surface may be coated with an emitter material to serve as the source of electrons and this coating may be composed of alkaline earth compounds, such as barium and strontium oxides applied in a spraying suspension with a suitable binder of nitrocellulose and amyl acetate. Alternatively, the coating may be applied as a complex matrix involving the preliminary spraying of a coating of nickel powder in a suitable binder on the surface of the cathode, the nickel layer being sintered thereon and then the barium and strontium coating applied to the sintered nickel surface to form a copious source of electron emission when the cathode surface is heated to operating temperature.

Since the cathode is of large area and must be held within close limits in space relation with the grid electrode 23, it is essential to inhibit axial expansion of the large cathode surface. This entails a special mounting of the active cathode surface from the cylindrical supporting member 27 to secure the above results yet at the same time permitting expansion and contraction of the hot cathode surface during operation to prevent distortion or buckling thereof and thereby altering the relation with the grid electrode. This is accomplished by inserting a flanged ring 37, preferably of grade A nickel, on the inner edge of the tubular member 27, the flange ring being brazed to the inner periphery of the tubular support, as shown in Fig. 3, and the juxtaposed portion of the ring in contact with the upper rim of the tubular member 27 being slotted, as shown in Fig. 4, to provide a plurality of segmental tabs 38 around the upper surface of the tubular member 27. A cylindrical metallic sleeve 39, preferably of grade A nickel, having a lower flanged rim 40 is attached to the tabs 38, preferably by welding, to resiliently mount the sleeve on the tubular member 27 yet securely anchor the sleeve thereto. The upper rim of the sleeve 39 is provided with a plurality of spaced inwardly bent ears 41 which are welded to the upturned rim 42 of the cathode disc 35 to mount the cathode disc in planar relation across the open end of the cathode casing. The flanged rim 42 of the cathode disc is about one-half the height of the corrugated disc portion of the cathode and is spaced from the corrugated portion by a recessed valley 43 to confine the active surface of the cathode to the corrugated portion in planar relation to the grid. The peripheral valley portion 43 of the cathode surface is welded on the

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lower surface to a metallic inner platform or supporting disc 44 which lies in parallel relation to the cathode surface and is provided with a central conical portion 45 to engage the upper stepped surface of an insulating sleeve bush 46. The bushing is seated centrally upon a metallic reflector plate 47 which is provided with bent-up angular legs 48 which are welded to the supporting disc 44, the reflector plate being provided with radial corrugations 49 to increase the rigidity of the reflector. An insulated tungsten heater 50, in the form of a flat spiral, is located between the cathode disc 35 and the mounting disc 44 for heating the cathode surface to emission temperature, the heater being attached at the outer end to the mounting disc 44 by welding and at the center to a conductor 51 extending through the bushing 46 and welded to the conductor 33 extending through the seal 32.

This construction provides a mounting assembly for the large area cathode surface which is formed of metal of high thermal impedance, to eliminate as much as possible the thermal loss in the hot cathode surface during operation and to prevent loss of heat to the relatively thick tubular member 27 which has high thermal conductivity characteristics. The slotted resilient ring 37 securing the cathode sleeve 39 to the tubular member 27 compensates for thermal stresses set up between the hot and relatively cooler portions of the cathode assembly and thereby prevents distortion thereof. Since the large cathode surface is anchored to the resilient ears 41 on the supporting sleeve of the cathode, the hot cathode surface 35 can expand and contract radially but not axially and the space relation with respect to the collateral grid surface 24 is maintained accurately throughout the operating life of the device.

The cylindrical cathode casing, as shown in Fig. 1, is supported in relation to the medial grid surface by a flared copper ring member 52 having a cylindrical portion which fits over the cylindrical surface of the tubular member 27 and a flared portion having a knife edge sealed to a bulbous vitreous glass insulating section 53, to form a hermetic seal at the joint between the glass and metal portions of the housing. A flanged sealing ring 54, also of copper, is provided with a knife edge portion 55 which is joined to the opposite end of the insulating section 53, the flange portion 54 being brazed to the undercut land surface 15 of the grid foundation ring.

The anode assembly and housing 11 includes a cup-shaped cylindrical casing 56 having a truncated conical base portion 57 forming a closure at the lower end which serves as the plane receptive surface of the anode disposed opposite the grid laterals 24. The anode is formed hollow to allow fluid cooling thereof to dissipate the heat energy imparted to the electron receptive surface of the anode. The anode casing is closed at the upper end by a closure plate 58 provided with a pair of openings which receive inlet and outlet stub pipes 59 and 60 for the circulation of a cooling medium, such as water, in the enclosed chamber of the anode casing. The interior of the casing has therein a central slotted standard 61 which is seated in a central recess 62 in the flat bottom of the anode and is secured to the cover 58 by a terminal plug 62a. The slotted standard carries a pair of partition plates 63 which extend across the diameter of the anode casing to form inlet and outlet channels for the circulation of the cooling medium, the plates 63 being

spaced from the bottom of the anode casing to form a communicating passageway between the inlet and outlet chambers. The anode is re-entrantly supported in a composite housing section which includes a sleeve member 64 of copper having a cylindrical portion embracing the cylindrical wall of the anode casing and a flared knife-edge portion sealed to a glass bulbous section 65. The opposite end of the glass section is sealed to a knife-edge copper flange member 66 which is joined to the land 14 of the grid supporting ring in juxtaposed relation to the grid electrode 24.

The procedure in securing the accurate spaced relation between the respective electrodes in the device, in accordance with this invention, to attain the desired electrical characteristics for the efficient operation of the device is as follows: After the separate cathode and anode casings are assembled and the housing portions thereof constructed, the method of assembly ensures accurate and constant space relation between the parallel cathode and anode surfaces with respect to the medial plane surface of the grid. The mounting of the anode will first be described. The grid structure 12 is placed in a suitable jig with all the elemental parts secured in a unitary assembly and the slotted grid surface 24 mounted in the central portion of the ring. The anode housing portion including the flared ring 64, insulating section 65 and flanged ring 66 is mounted on the land 14, but not in sealing relation; that is, the flange 66 is accurately placed in facing relation to the land 14 of the grid ring 12. The anode casing 56 is then lowered into the housing of the anode until the flat surface of the anode makes contact with the edges of the slats 24 of the grid. The anode casing is then backed out by a micrometer gauge, which may be attached to the jig supporting the anode, until the distance between the grid and anode surfaces is of the order of .080 inch to provide the anode-grid spacing. The anode casing is then sealed to the housing by brazing the ring 64 to the anode casing 56 by a solder filling 67, which may be a solder of the composition of 40 per cent silver and 60 per cent copper having a melting point of 910° C. The anode and housing assembly 11 is then removed from the grid partition ring 12 and the mounting of the cathode surface with respect to the grid is performed. In this operation, the grid ring 12 is reversed and the cathode housing including the flared ring 52, insulating section 53 and flange ring 54 is placed on the land 15 of the grid ring and the cathode assembly inserted through the housing until contact is made with the grid laterals 24 of the grid assembly. A micrometer gauge, which may be attached to the jig supporting the cathode, measures the distance between the cathode and grid surfaces and the cathode assembly is backed away from the grid by a distance of the order of .030 inch to provide the proper cathode grid spacing in the device. The cathode assembly is then sealed to its respective housing by a solder brazing operation at the point 68 with the 40-60 alloy solder employed for the anode seal. The combined cathode and housing assembly is then removed from the grid ring to facilitate the further assembly of the complete structure.

The interelectrode capacity between the active surfaces of the large diameter electrodes is reduced, in accordance with a feature of this invention, by a coupling capacity shield or ring formed of two semiconical sections 69 and 70

which coaxially surround and are spaced from the conical section 57 of the anode. The two shield sections are provided with projecting wings 71 at opposite ends of the sections which are welded to opposite sides of a vane 72 projecting from the upper ends of a pair of vertical gable-shaped metallic radiators 73. The latter extend through oval-shaped openings or apertures 74 in oppositely disposed positions on the internal supporting ring portion 17 of the grid ring 12. The vertical radiators 73 are welded to bent ears on outwardly extending wings 75 projecting from opposite sides of the cathode supporting sleeve 39.

When the capacitive element is mounted on the cathode assembly with the cathode housing affixed to one side of the grid assembly 12, the anode housing and assembly is placed in position with a preformed ring of solder, for example having the composition of 15 per cent silver, 80 per cent copper and 5 per cent phosphor, placed on the lands 14 and 15 in interposed relation to the seal rings 54 and 66. The solder ring has a thickness of the order of .005 inch and the solder has a melting point of 725° C. so that the sealing flanges of the respective housings on opposite sides of the grid ring may be fused to the lands 14 and 15 at a lower temperature than the other brazed joints in the complete assembly. The brazing of the medial joints to the grid ring may be performed in a hydrogen-filled oven without deleteriously affecting the other brazed joints and the final assembly will result in accurate spaced relation between the respective large diameter surfaces in the active portions of the electrodes.

The foundation ring of the grid assembly serves not only as a grounding shield between the input and output circuits on opposite sides of the grid, but also to accurately register the collateral surfaces of the active cathode and anode electrodes on opposite sides of the grid. The cooperating sealing flanges of these electrode assemblies provide strong mechanical and hermetically sealed joints with the ring. Furthermore, the symmetrical unitary arrangement of the electrodes insures constant stability in the spacial relation between the active surfaces in the discharge path and freedom from variation due to temperature changes during operation. The tubular extremities of the cathode and anode constructions also facilitate the coupling of these electrodes to terminating coaxial transmission lines which, in cooperation with the cavity resonator circuit employed in conjunction with the device, provide the electrical components for deriving the highest efficiency power output.

The sealed joint between the anode and housing and also that between the cathode and its housing, as shown in Fig. 1, provides a compact assembly which materially reduces the over-all length of the device for a given power output. However, if the diameters of the respective electrodes and telescopic housing ring portions are not accurately machined to completely seal the contacting cylindrical walls adjacent the end brazed seals, pumping or evacuation of the device may be prolonged to remove the last vestiges of air and gas from the minute crevices formed between these walls.

This possible condition may be overcome by a construction illustrated in Fig. 5. The anode wall 56 may be machined or reduced in thickness on the portion joining the open end to the tapered bottom portion 57 to provide a concentric integral skirt portion 76 which is spaced from the

wall 56 by an annular groove 77. This construction provides a restricted cylindrical ledge portion which is in contact with the inner cylindrical surface of the flared sleeve 64 of the housing. A feature of the dependent skirt 76 is the tendency of the solder to flow during the sealing operation of the housing to the anode into the crevices between the wall 64 and the skirt 76. As the excess molten solder reaches the lower edge of the skirt, it flows circularly around the edge of the skirt instead of dropping off and this action seals the interior joint between the skirt 76 and the wall 64. The minute crevices between the wall 64 and skirt 76 are then sealed off from the volume space in the housing of the anode and the volume space may be readily evacuated by the usual pumping procedure.

The same form of joint may be applied between the cathode casing 27 and the housing sleeve 52 to improve the sealed joint therebetween.

While the invention has been disclosed with respect to certain aspects of the complete assembly of the device, it is, of course, understood that various modifications may be made in the detailed assembly without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electronic discharge device comprising a hollow metallic cathode structure having a flat emitting surface of large area, a hollow metallic anode structure having a flat surface oppositely disposed in spaced relation to said cathode emitting surface, a perforated grid electrode medially disposed in relation to said cathode and anode surfaces, annular insulated housing portions disposed about said cathode and anode structures, said housing portions having cylindrical metallic sleeve members and the peripheral walls of said cathode and anode structures being cylindrical and each being fitted within a respective sleeve member, and an annular foundation for said grid electrode sealed to and between said housing portions.

2. An electronic discharge device comprising a plane medial grid electrode, a metallic ring supporting said grid having an external peripheral portion having foundation surfaces on opposite sides thereof, a metallic member secured to each of said surfaces on opposite sides of said portion, an annular insulating wall sealed to each member and extending away from said external portion on opposite sides thereof, a metallic sleeve sealed to the opposite end of each wall to form a housing, and hollow metallic anode and cathode casings having plane surface areas closely adjacent opposite sides of said medial grid and reentrantly supported by the respective sleeves.

3. An electronic discharge device comprising a hollow metallic structure having a flat emitting surface of large area, a hollow metallic anode structure having a flat surface oppositely disposed in spaced relation to said cathode emitting surface, a grid blank medially disposed in relation to said cathode and anode surfaces, said blank having parallel slots therein and slats formed by said slots and integral with said blank bent in approximately perpendicular relation to said blank, an annular metallic base member for said grid electrode blank, and housing portions coaxial with said cathode and anode structures, said housing portions having metallic sleeve members joined to the walls of said cathode and anode structures and metallic flange members projecting beyond said cathode and anode sur-

faces, said flange members being sealed to said base member to maintain predetermined space relation between said cathode and anode surfaces on opposite sides of said grid electrode.

4. An electronic discharge device comprising a hollow metallic cathode structure having a flat emitting surface of large area, a hollow metallic anode structure having a flat surface oppositely disposed in spaced relation to said cathode emitting surface, a perforated grid electrode medially disposed in relation to said cathode and anode surfaces, composite metal and glass housing portions mounting said cathode and anode structures within said portions, a metallic ring support for said grid electrode sealed in juxtaposed relation to said housing portions, and an annular capacitive element coaxially surrounding said anode structure.

5. An electronic discharge device comprising a hollow metallic cathode structure having a flat emitting surface of large area, a hollow metallic anode structure having a flat surface oppositely disposed in spaced relation to said cathode emitting surface, a perforated grid electrode disposed between said cathode and anode surfaces, composite metal and glass housing portions mounting said cathode and anode structures within said portions, a metallic ring support for said grid electrode sealed in juxtaposed relation to said housing portions, an annular capacitive element coaxially surrounding said anode structure, and means supporting said element from said cathode structure.

6. An electronic discharge device comprising a hollow metallic cathode structure having a flat emitting surface of large area, a hollow metallic anode structure having a flat surface oppositely disposed in spaced relation to said cathode emitting surface, a perforated grid electrode disposed between said cathode and anode surfaces, composite metal and glass housing portions mounting said cathode and anode structures within said portions, a metallic ring support for said grid electrode sealed in juxtaposed relation to said housing portions, an annular capacitive element coaxially surrounding said anode structure, and heat radiator supports extending from said cathode structure to said capacitive element.

7. An electronic discharge device comprising a hollow metallic cathode structure having a flat emitting surface of large area, a hollow metallic anode structure having a flat surface oppositely disposed in spaced relation to said cathode emitting surface, a perforated grid electrode medially disposed in relation to said cathode and anode surfaces, composite metal and glass housing portions mounting said cathode and anode structures within said portions, a metallic ring support for said grid electrode having openings therein between said grid and the periphery thereof, said support being sealed in juxtaposed relation to said housing portions, an annular capacitive element surrounding said anode structure, and heat radiator supports extending through said openings in said ring support and between said capacitive element and said cathode structure.

8. A hollow cathode structure comprising a tubular metallic casing, an external closure for said casing having a sealing plug extending outwardly therefrom, a cylindrical flanged sleeve member secured to the opposite end of said casing, said ring member having resilient portions bent inwardly from the free end, a metallic disc joined to said resilient portions and closing the

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opposite end of said casing, said disc having an electron emissive coating thereon, an auxiliary metallic supporting disc secured in spaced relation to the coated disc within said casing, a spiral insulated heater element between said discs having one end attached to said discs, a central insulator carried by said auxiliary disc, and a conductor extending between the other end of said heater element and the sealing plug on the outer end of said casing.

9. A hollow cathode structure comprising a tubular metallic casing, an external closure for said casing having a sealing plug thereon, a slotted metallic ring engaging the opposite end of said casing, a metallic sleeve member having a flanged portion secured to portions of said slotted ring, said sleeve member having inwardly bent ears projecting from one end, a metallic disc having corrugations secured to said ears and closing the opposite end of said casing, said disc having an emissive coating on the outer surface, an inner platform secured in spaced relation to said corrugated disc, a heater element supported on said platform adjacent said disc, one end thereof being attached to said platform, and a lead-in conductor extending through said sealing plug and connected to the other end of said heater element.

10. A hollow cathode structure comprising a tubular metallic casing, an external closure for said casing having a sealing plug extending therefrom, a slotted metallic ring engaging the opposite end of said casing, a metallic sleeve member having a flanged portion secured to portions of said slotted ring, said sleeve member having inwardly bent ears projecting from one end, a metallic disc having radial corrugations secured to said ears and closing the opposite end of said casing, said disc having an emissive coating on the outer surface, an inner platform secured in spaced relation to said corrugated disc, a reflector attached to said platform and spaced from said sleeve member, an insulator bushing seated between said platform and reflector, a heater element supported on said platform adjacent said disc, one end thereof being attached to said platform, and a lead-in conductor extending through said sealing plug and insulator for connection to the other end of said heater element.

11. An anode structure comprising a cup-shaped metallic casing, an apertured closure member secured to the open end of said casing, inlet and outlet connections extending from said closure, a central standard extending between said closure and the base of said casing, and a partition supported by said standard and separating said casing into communicating chambers leading to said connections.

12. An anode structure comprising a cup-shaped metallic casing, an apertured closure member secured to the open end of said casing, inlet and outlet connections extending from said closure, a slotted standard extending between said closure and the base of said casing, a pair

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of plates secured in said slotted standard and extending outwardly to the opposite wall of said casing, and a terminal plug on said closure secured to said standard.

13. A high frequency electronic discharge device comprising a metallic mounting ring having an external peripheral portion with an undercut band in each surface, a plane grid electrode in the center of said ring, a hollow metallic anode disposed on one side of said plane grid, a housing supporting said anode in reentrant relation thereto and spaced in collateral relation to said grid, a hollow metallic cathode disposed on the opposite side of said plane grid, another housing supporting said cathode in reentrant relation thereto and spaced in collateral relation to said grid, each of said housings having a metallic flange portion sealed to one of the undercut bands in said mounting ring, a flared metallic sleeve portion sealed to the respective hollow cathode and anode, and connecting glass portions joined to said flange and sleeve portions.

14. A high frequency electronic discharge device comprising a metallic mounting ring having an external peripheral portion with an undercut band in each surface, a slatted plane grid electrode in the center of said ring, said ring having oppositely disposed openings between said peripheral portion and said grid electrode, a plurality of bracing wires secured to the slats of said grid electrode in radial and arcuate relation to prevent distortion of said slats, a hollow metallic anode disposed on one side of said plane grid, a housing supporting said anode in reentrant relation thereto and spaced in collateral relation to said grid, a hollow metallic cathode disposed on the opposite side of said plane grid, another housing supporting said cathode in reentrant relation thereto and spaced in collateral relation to said grid, each of said housings having a metallic flange portion sealed to one of the undercut bands in said mounting ring, a flared metallic sleeve portion sealed to the respective hollow cathode and anode structures, connecting glass portions joined to said flange and sleeve portions, wing extensions projecting from opposite sides of said hollow cathode, a tapered metallic two-section sleeve member coaxially surrounding and spaced from said hollow anode, and metallic radiator supports extending through said ring openings and connecting said sleeve member to said wings on said cathode structure.

JOHN W. WEST.

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