Dec. 21, 1948. J. M. CARTER 2,456,861

GENERATOR AND CATHODE CONSTRUCTION FOR ELECTRICITY OF ULTRA HIGH FREQUENCY

Filed May 6, 1943 2 Sheets-Sheet 1

Fig. 1.

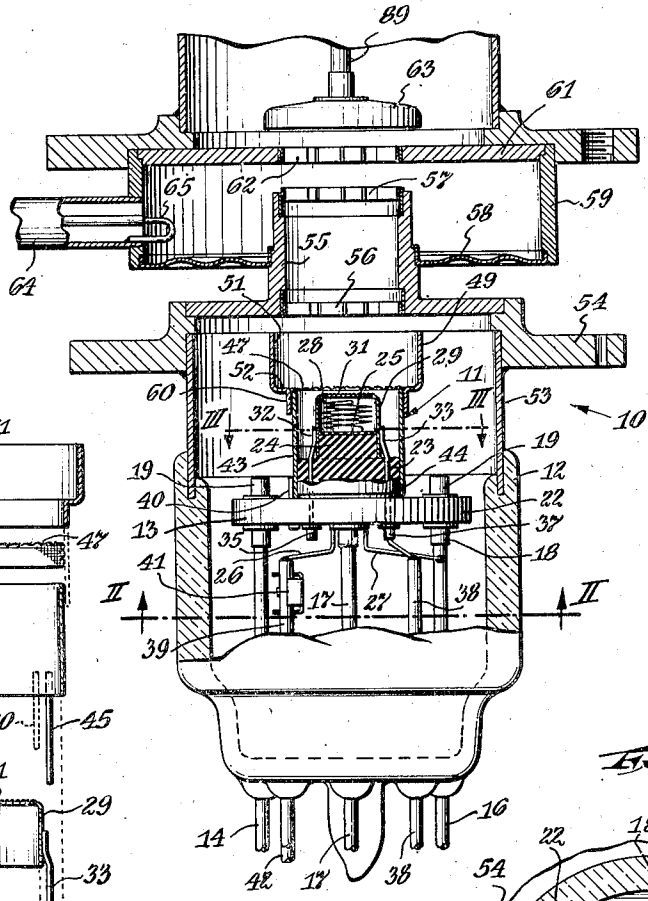


Fig. 4.

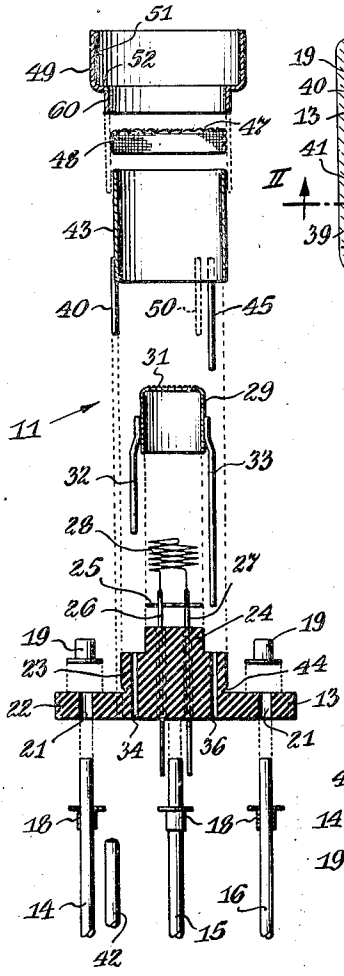


Fig. 2.

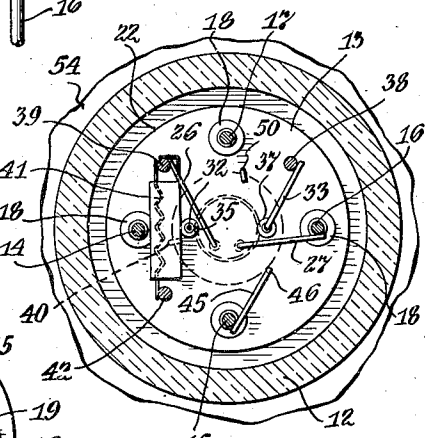
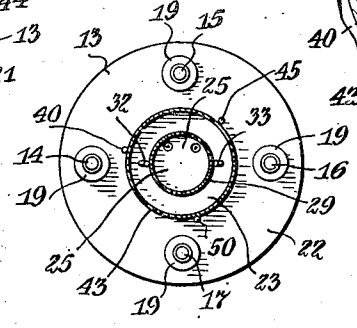


Fig. 3.



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Fig. 6.

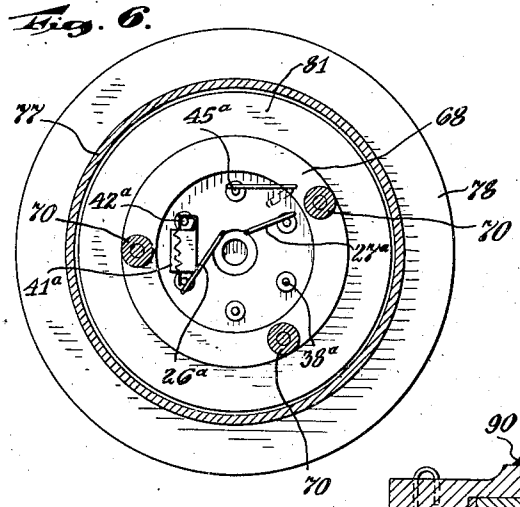
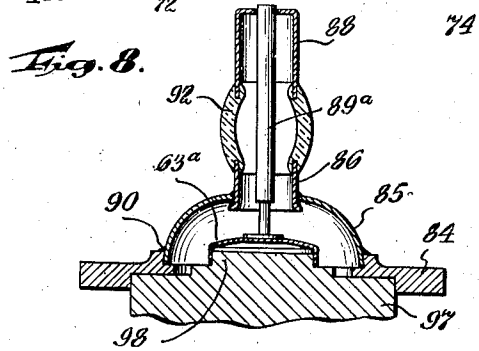


Fig. 5.

Fig. 7.

Fig. 8.



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GENERATOR AND CATHODE CONSTRUCTION FOR ELECTRICITY OF ULTRA HIGH FREQUENCY

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Application May 6, 1943, Serial No. 485,852

14 Claims. (Cl. 315—5)

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This invention relates to generators for electricity of ultra-high frequency, and more particularly, to the general construction of such and the cathode mounts thereof.

The primary objects of my invention, generally considered, are to provide a novel form of generator for electricity of ultra-high frequency and a cathode mount therefor involving a heater element, a cathode proper, a shield, a grid, and a focusing ring, all so arranged that they may be made cheaper, easier and better than previous similar devices, with a reduction in the number of operations, and the avoidance of interior contamination due to sealing, whereby they are more readily adapted to production methods and require fewer jigs and parts.

Another object of my invention is to provide a cathode mount for ultra-high frequency devices, involving a heat shield which supports an associated grid and focusing ring adjacent its upper end, and which is adapted to be assembled, quickly and accurately, with an insulative cathode support, a cathode cup, and heater filament.

A further object of my invention is to provide a generator for electricity of ultra-high frequency having an electron-emissive-cathode mount, an envelope consisting in part of a cavity resonator device associated with said mount, with the latter involving an insulative base, a cathode cup member telescoped with a portion of said base and supported on the upper surface thereof, leads for the cup and filament passing through said base, a cathode shield telescoped with said base portion, and a grid and focusing ring supported on the upper end of said shield.

A still further object of my invention is to manufacture reflex Klystrons from standard receiving-type metal tube parts, instead of special parts prepared for the individual tube, thus eliminating a large quantity of glass, "Kovar" and other critically needed materials and equipment.

An additional object of my invention is the manufacture of devices, such as reflex Klystrons, with the elimination of the eight-lead glass dish stem as the weakest element of such.

Another object of my invention is to eliminate poisoning of the cathode and general contamination of the inside of the tube, due to sealing with fires, by assembling and brazing the device in a hydrogen atmosphere.

A still further object of my invention is to more accurately align the cathode and refletcor in a reflex Klystron by using a novel method of manufacture in order to provide such devices with greater efficiency and power output.

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Other objects and advantages of the invention, relating to the particular arrangement and construction of the various parts, will become apparent as the description proceeds.

Referring to the drawing illustrating the invention:

Fig. 1 is a fragmentary axial sectional view of an electron beam device for generating electricity of ultra-high frequency and involving one embodiment of the invention, portions thereof being shown in elevation.

Fig. 2 is a fragmentary transverse sectional view on the line II—II of Fig. 1, in the direction of the arrows.

Fig. 3 is a fragmentary transverse sectional view on the line III—III of Fig. 1, in the direction of the arrows.

Fig. 4 is an exploded view of the cathode mount.

Fig. 5 is a fragmentary axial sectional view, similar to Fig. 1, but showing a modification.

Fig. 6 is a transverse sectional view on the line VI—VI of Fig. 5, in the direction of the arrows.

Fig. 7 is an axial sectional view, partly in elevation, showing parts of the device during manufacture.

Fig. 8 is a transverse sectional view corresponding to Fig. 7 but showing other parts of the device during manufacture.

Referring to the drawing in detail, and first considering the embodiment of my invention illustrated in Figs 1 to 4, inclusive, the reference numeral 10 designates the generator or reflex Klystron, in general. The numeral 11 designates the cathode mount construction in general, which is supported within an evacuated envelope 12, generally circular in cross-section, on an insulator 13, held in place by supporting leads 14, 15, 16 and 17 which pass through the lower end of the envelope. The manner in which these leads support the insulator 13, which may be formed of porcelain, is shown most clearly in Figs. 1 and 4, that is, they desirably have collars 18 secured to intermediate portions thereof which act as stops for the insulator 13, said insulator being held in place on the upper end portions of said leads by collar devices 19, after insertion of said leads through corresponding apertures 21.

The insulator 13 comprises a lower plate portion 22, generally circular in outline, from which etxends a generally cylindrical portion 23 coaxial therewith, and terminating at its upper end in a coaxial cylindrical projection 24 of smaller size. The projection 24 desirably supports a reflector

plate 25, through which and the insulator 13 extend leads 26 and 27 for the cathode-heating filament 28. The cathode proper is in the form of a downwardly opening cup member 29, of nickel or other suitable metal, carrying on its upper or closed end, electron-emissive material 31, such as a mixture of oxides of barium and strontium.

Said cathode 29 carries support wires 32 and 33, the former of which merely passes through a corresponding aperture 34 in the insulator 13 and is secured in place by means of collar 35, while the other passes through corresponding aperture 36, is secured in place by a similar collar 37, and continues on to unite with cathode lead wire 38 which passes out of the envelope in a direction parallel to the leads 14 to 17, inclusive. The heater filament leads 26 and 27 likewise respectively unite with leads 39 and 16, the former of which has a getter device 41 carried between it and associated lead 42, which latter passes out of the envelope like the leads 14 to 17, inclusive, 38 and 39.

The cathode mount also includes a heat shield 43 which telescopes with the cylindrical portion 23 of the insulator 13, and is desirably clamped in place by bending its lower edge portion into the groove 44 at the base thereof. The heat shield 43 carries a lead 45, which passes through a corresponding aperture 46 in the insulator 13 and then connects with the lead-in conductor 15, and wires 49 and 50. The lower or free ends of said wires 49 and 50 are desirably bent after assembly to holding positions, as shown most clearly in Fig. 2.

In the present embodiment, the upper end of the heat shield 43 carries a grid 47, the peripheral portion of which is flanged as indicated at 48, and telescopes over the upper end of said shield. Said grid is desirably held in place by the focusing ring 49 consisting of a cylindrical body portion 51 flanged inwardly, as indicated at 52. Said inwardly projecting plane annular flange 52 terminates in a downwardly projecting cylindrical flange 60 which telescopes over the downwardly depending flanged portion 48 of the grid 47. All three parts may be secured together by running solder into the space between the telescoping portions thereof.

The envelope portion 12 is completed by the metal cylindrical portion 53, which may be of "Kovar," which is a well-known nickel-cobalt-iron alloy more specifically defined in the Lempert et al. Patent No. 2,279,831, dated April 14, 1942, or other material which unites readily with the glass of the lead-in conductor carrying portion 12. Said cylindrical portion 53 is connected to a flange element 54 at its upper end, which in turn carries an annular plate and cylindrical flange member 55, having grids 56 and 57, and being united to a flexible wall 58 of a cavity resonator device 59. The upper wall 61 of the resonator 59 also carries a grid 62 and portions which may be conventional to complete the envelope and support a reflector 63, as by means of lead-in conductor 89. In operation, suitable power sources are connected, as through the various leads disclosed, so that a beam of electrons from the cathode 29, due to heating it by means of its preferably tungsten filament 28, shall pass successively through the grids 47, 56, 57 and 62, to be reversed by the reflector 63, held in place in any desired manner, or as disclosed in Fig. 5, and directed back through the cavity resonator device 59, to effect generation of the desired power, as will be understood. The wiring may be generally as illustrated in Fig. 3 of the Clifford et al. application, Ser. No. 470,582, filed December 30, 1942, and now U. S. Patent No. 2,454,306 dated November 23, 1948, omitting the adjusting features 47, 48 and 49.

From the foregoing disclosure, the construction will be recognized as a hollow-body resonant micro-wave generator of the reflex type, where the upward or forward moving electrons are "bunched" in passing though the construction between the grids 57 and 62, giving up energy while passing back therethrough in "bunches" on the reflected or return path. Tuning of the resonant chamber 59 may, therefore, be obtained by changing the space between the grids 57 and 62 and the distance between the walls 58 and 61, in any desired manner, or as illustrated in Fig. 5, by virtue of the flexibility of the wall 58, which is desirably provided with corrugations concentric about the tube axis. The generated energy may be withdrawn by the coaxial line 64, using the loop device 65.

Referring now to the embodiment of my invention illustrated in Figs. 5 to 8, inclusive, the character 10a designates, in general, an improved form of reflex Klystron. The reference numeral 11a designates the cathode mount, in general, which is supported within an evacuated envelope 12a on insulator 13a which may be formed of porcelain or similar material. Said plate is held in place by rods 66, the heads 67 of which are desirably countersunk in a ring 68, which is in turn secured, as by soldering or welding to a flanged annular member 69 carrying insulation 71, which may be glass and provided with an exhaust tube 72.

The insulator 13a is held in place by means of collar devices 19a which are soldered or otherwise suitably secured in place on the upper or other ends of the rods 66. Said rods 66 pass through hollow cylindrical spacing elements 70, the construction thereby providing for holding the insulator 13a and the supporting ring element 68 in the proper assembled relation. Through this insulator also pass lead-in conductors, those numbered 26a and 27a being from the cathode heater filament 28a, which may be like the filament 28 of the preceding embodiment and mounted in a similar manner above a reflector plate 25a. The other leads include that designated 38a to the cathode 29a, which may be formed like the cathode 29 of the preceding embodiment, and the lead 45a for the cathode heat shield 43a which carries a grid 47a and focusing ring 49a, as in the preceding embodiment.

All of the leads, that is, those numbered 26a, 27a, 38a, 42a, and 45a, those numbered 26a and 42a including in circuit a getter device 41a, as in the preceding embodiment, finally pass to corresponding outer contact members 73 which are, in turn, held in outer insulator disk 74, which may be formed of Bakelite or similar material. The insulator 74 may carry an inwardly opening pocket portion 75 which serves as a protector for the exhaust stub 72, as well as means to insure that the device is properly inserted in a receiving socket, such as an outstanding longitudinal rib 76 on said pocket portion 75.

The insulator 13a may be identical with the member 13 of the preceding embodiment and the parts of the cathode mount supported thereon may be assembled therewith in a manner identical with that described in connection with the first embodiment, and illustrated in exploded view

in Fig. 4, so that further description here is unnecessary. However, instead of being enclosed in a part glass or vitreous envelope, the present cathode mount is enclosed in an all-metal envelope portion consisting of a hollow steel or other suitable metal cylinder or shell 77, provided with an outstanding lower or outer flange 78, to which the outstanding annular flange 79 of a supporting base member 81 for the flanged annular member 69 and suitably connected ring 68, is secured, which completes the lower sealed portion of the envelope.

The outer base portion of the envelope consists of a ring 82, annular in section, as illustrated, the outstanding flange portion 83 of which is secured to the flange 79 in any desired manner, as by means of welding or soldering. A desirable construction involves the simultaneous welding of all of the three flanges 78, 79 and 83 together. The Bakelite or other contact-holding insulator disk 74 is secured to the ring 82 in any desired manner, as by means of cement or tabs on the member 82 bent into notches in the disk 74.

The envelope portion 12a is completed by the flange element 54a at its upper end which, in turn, carries a plate and cylindrical flange member 55a, with grids 56a and 57a. The member 55a is united to a flexible wall portion 58a of a hollow generally cylindrical cavity resonator device 59a. The upper wall 61a of the cavity resonator 59a also carries a grid 62a as well as a top mounting ring 84 to which the metal tube can 85 is secured, as by copper brazing in a hydrogen furnace as indicated at 90. The tube can 85 is centrally apertured and connected to an eyelet 86, which may be formed of "Kovar" or other material which seals well to glass, as by copper brazing 87 in a hydrogen furnace, preferably at the same time as the connecting of the parts 84 and 85. The upper outer contact member 88, which may also be formed of "Kovar" or the like, carries the reflector 63a, of nickel or the like, as by means of its desirably steel supporting rod 89a, the outer or upper end of which is sealed thereto as by solder indicated at 91. The contact 88 is secured to the eyelet 86 by means of a glass or vitreous sleeve 92.

Adjustment of the frequency of the electrical energy generated in the device, by varying the distance between the walls 61a and 58a, is effected by flexing the latter. This is accomplished by the adjusting screws 93 (only one of which is illustrated) threaded into the top mounting ring 84, held in adjusted position by nuts 94, and with their lower ends socketed to receive the rounded studs 95 mounted in flange element 54a, against the action of the tension coil springs 96, which act to pull the members 54a and 84 together.

From the foregoing disclosure, it will be seen that we have a hollow resonant micro-wave generator of the reflex Klystron type, as an improvement on that shown in Figs. 1 to 4, inclusive, whereby the upward or forward moving electrons from the cathode 29a are "bunched" in passing through the constriction between the grids 57a and 62a, giving up energy while passing back therethrough in "bunches" on the reflected or return path. The generated energy may be withdrawn along the coaxial line 64a, as by using the loop device 65a.

In the former tube construction, generally represented, except as to the cathode mount, in Figs. 1, 2 and 3, the cathode mount is held on a relatively fragile glass stem, placed in a sealing fixture, and laboriously aligned so that when the fixture is held in a chuck and rotated, the focusing

ring 49 will run true to within .001". It is then placed in a lathe and sealed to the cavity resonator or shell assembly, after the latter has been aligned in said lathe to approximately the same accuracy.

As can readily be seen, this is a slow process which requires very skillful operators. It may inadvertently result in poor alignment giving low output and loss of the tube.

The improved tube of the embodiment of Figs. 5 and 6, however, may be manufactured by first mounting the cathode assembly on the base member 81, to within an accuracy of approximately 1/64" to 1/32", and then projection welding the outstanding flanges 78, 79 and 83, using a removable jig or plug 99 to align the focusing ring 49a and metal shell 77 during said welding operation, as illustrated in Fig. 7, thereby securing a very accurate alignment between said ring and shell. Welding may be facilitated by forming the flanges 78 and 83 with the annular corrugations 100 and 100.

In the tube illustrated in Figs. 1, 2 and 3, the reflector 63 has been welded to a "Kovar" lead 89 that had previously been beaded and a glass flare attached. In such a case it had to be aligned so that the axial and lateral eccentricity of the reflector cup rim was not greater than .001", when the lead on the opposite side of the flare is held in a chuck and rotated. This can only be obtained by bending the "Kovar" lead until the reflector cup has the desired alignment. At best, this is difficult, as the strained "Kovar" lead returns to an unstrained position during sealing, resulting in a distorted position of the reflector.

In accordance with the embodiment illustrated in Figs. 5 and 6, the reflector is sealed into the shell assembly in a manner similar to the handling of the cathode. The reflector-supporting parts, that is, the top mounting ring 84, the metal tube can 85, the "Kovar" eyelet 86, the contact 88, and the connecting glass part 92, are assembled in a lathe to within approximately the same accuracy as the cathode mount. The alignment of the reflector in the tube is probably the most critical point in the manufacture. After cleaning, the assembly is placed over the aligning jig or plug 97, as illustrated in Fig. 8. The reflector, attached to heavy steel lead 89a, is placed over in nesting relation with the projection 98 of said aligning plug 97, as illustrated, and the reflector lead 89a brazed to the "Kovar" contact cup 88 where the former protrudes, as indicated at 91 in Fig. 5.

From the foregoing disclosure, it will be seen that I have devised an improved cathode mount assembly which may be used in either the form of Klystron illustrated in Figs. 1, 2 and 3 or as illustrated in Figs. 5 and 6. I prefer the latter construction, whereby the following advantages may be obtained:

1. Standard receiving-type metal tube parts may be used, instead of special parts prepared for one tube, to eliminate a large quantity of glass, "Kovar" and other critical material.

2. The number of operations may be reduced and the assembly simplified.

3. The present eight-lead glass-dish stem, considered to be the weakest manufacturing point in the tube, has been eliminated.

4. The tube is not subjected to vibration troubles because of the greater rigidity with which the cathode and reflector are mounted.

5. Poisoning of the cathode and general contamination of the inside of the tube, due to seal-

ing with fires, has been eliminated, by substituting brazing in a hydrogen atmosphere.

6. Noticeably greater efficiency and power output is obtained due to the more accurately aligned cathode and reflector.

Although preferred embodiments of my invention have been disclosed, it will be understood that modifications may be made within the spirit and scope of the appended claims.

I claim:

1. A generator for electricity of ultra-high frequency, comprising an electron-emissive cathode mount, an envelope comprised in part of a cavity resonator arranged coaxial with said mount, a reflector on the side of said resonator opposite to said mount, the latter comprising a cathode cup member, a heater filament enclosed in said cup member and supported in said envelope, a hollow cylindrical cathode shield, a grid provided with a peripheral flange telescoped with the upper end of said shield, a focusing ring fitting over the grid flange and secured to said shield, and leads connected to said electrodes for energizing said filament and impressing the desired potentials on said cathode, resonator, and reflector to cause an electron beam to pass from said cathode to said reflector and be directed back through said cavity resonator.

2. A generator for electricity of ultra-high frequency, comprising an electron-emissive cathode mount, an envelope comprised in part of a cavity resonator arranged coaxial with said mount, a reflector on the side of said resonator opposite to said mount, the latter comprising an insulator having an upper projection carrying an extension of reduced cross section, a cathode cup member telescoped with said reduced extension, a heater filament enclosed in said cup member and supported on said extension, leads to said cup member and filament, passing through said insulator, a hollow cylindrical cathode shield telescoped with said upper projection, a grid provided with a peripheral flange telescoped with the upper end of said shield, a focusing ring fitting over the grid flange and secured to said shield, and leads connected to said electrodes for energizing said filament and impressing the desired potentials on said cathode, resonator, and reflector to cause an electron beam to pass from said cathode to said reflector and be directed back through said cavity resonator.

3. A generator for electricity of ultra-high frequency comprising a cathode mount, an envelope comprising an insulator on which said cathode mount is fixed, a metal ring to which said insulator is connected, a hollow cylindrical metal portion surrounding said mount, insulator and ring, and provided with an outstanding end flange, a metal end portion closing the flanged end of said cylinder, said end portion having an outstanding flange connected to the outstanding flange on said cylindrical portion, the intermediate portion of said end member being apertured, and a flanged annular member connecting said ring and end member and carrying a central insulating closure portion through which leads to said cathode mount extend.

4. A generator for electricity of ultra-high frequency comprising an electron-emissive cathode mount, an envelope comprising a cavity resonator device forming part thereof, the remainder of said envelope comprising an insulator on which said cathode mount is fixed, a metal ring to which said insulator is connected, a hollow cylindrical metal portion surrounding said mount, insulator and ring and provided with an outstanding end flange, a flanged annular metal member secured to the unflanged end of said metal cylinder, means connecting said annular member to said resonator, a metal end portion having an outstanding flange connected to the outstanding flange on said cylindrical portion, the intermediate portion of said end member being apertured, a flanged annular member serving to connect said ring and end member and carrying a central insulating closure portion provided with an exhaust tube and through which leads to said cathode mount extend, and a base device comprising a flanged annular member carrying an insulating disk with outstanding contact devices to which said leads are connected and an outstanding peripheral flange secured to said outstanding flange on said end closure member.

5. An electrode and mount assembly for a discharge device comprising a cup member carrying electron-emissive material, a heater filament enclosed in said cup member, a hollow cylindrical cathode shield enclosing said cup member, a grid provided with a peripheral flange telescoped with the upper end of said shield, a focusing ring fitting over the grid flange and secured to said shield, and leads connected to said electrodes for energizing said filament and impressing desired potentials on said cup and shield.

6. An electrode and mount assembly for an electron discharge device comprising an insulator having a projection-carrying extension of reduced cross section, a cathode cup member telescoped with said reduced extension, a heater filament enclosed in said cup member and supported on said extension, leads to said cup member and filament passing through said insulator, a hollow cylindrical cathode shield telescoped with said projection, a grid with a peripheral flange telescoped with the upper end of said shield, a focusing ring fitting over the grid flange and secured to said shield, and leads connected to said electrodes for energizing said heater filament and impressing desired potentials on said cathode and focusing ring.

7. The method of making an envelope for an electron-discharge device comprising connecting a cavity resonator device to one end of a hollow metal cylinder, closing the other end of said cylinder by means of an annular flanged member carrying a cathode mount and insulator through which leads to said mount extend, connecting said leads to outer contact devices embedded in an insulating disk carried by a base comprising a flanged metal annular portion, and securing said base over said annular member.

8. The method of connecting parts of a generator for electricity of ultra-high frequency, including a cathode mount assembly and a focusing ring, in a hollow cylindrical metal envelope portion, comprising positioning said cathode mount assembly on an annular metal base member provided with an outstanding flange, placing the hollow cylindrical portion so that its lower end rests on said base flange, fitting a centering jig, so that one portion is telescoped with the upper end of said hollow cylindrical member and another portion with the focusing ring, and then uniting the outstanding flanges of said hollow cylindrical member and cathode assembly base portion.

9. The method of connecting parts of a generator for electricity of ultra-high frequency, including a cathode mount assembly and a focusing ring, in a hollow cylindrical flanged metal

envelope portion, comprising positioning said cathode mount assembly on an annular metal base member provided with an outstanding flange, placing the hollow cylindrical portion with its flanged end resting on said base flange, fitting a centering plug member, so that one portion is telescoped with the upper end of said hollow cylindrical member and another portion with the focusing ring, and then welding together the outstanding flanges of said hollow cylindrical member and cathode mount assembly base portion.

10. The method of assembling a reflector cup and support rod with respect to a portion of a metal enclosing envelope comprising placing a mounting ring, a metal tube can, and an associated eyelet in contact and brazing them together, connecting an outer contact member to said eyelet by means of a glass connecting part, placing the assembly over an aligning jig, with the mounting ring telescoped with a portion of said jig and the reflector cup telescoped with a concentric projection thereon and the support rod of said cup projecting through a central aperture in said outer contact member, and uniting the protruding end of said rod to the adjacent portion of said contact member.

11. A generator for electricity of ultra-high frequency comprising a cathode mount, and insulator on which said mount is fixed, a cup-shaped vitreous envelope portion, lead-in conductors passing through said envelope portion and supporting said insulator, a hollow metal cylindrical portion with one end connected to the edge of said vitreous envelope portion, and a cavity resonator connected to the other end of said metal cylindrical portion completing the envelope.

12. The method of making an electron discharge device comprising forming a hollow metal cylinder, forming a cavity resonator, forming a closure member comprising an annular flanged metal plate carrying a central glass portion, mounting contact members in said glass portion, supporting an insulator from said closure member by means of hollow cylindrical spacer elements disposed therebetween and connected thereto by rods passing therethrough, mounting a cathode and heating filament therefor on said insulator, connecting said filament to a pair of said contact members, connecting said cavity resonator to one end of said cylinder, placing said cathode and filament in said cylinder, and closing the other end of said cylinder by means of said flanged metal plate.

13. The method of making an electron discharge device comprising forming a hollow metal cylinder, forming a cavity resonator, forming a closure member for said cylinder, mounting contact members in and supporting an insulator from said closure member, mounting a cathode and heating filament therefor on said insulator, connecting said filament to a pair of said contact members, connecting said resonator to one end of said cylinder, and mounting said closure member on the other end of said cylinder in completing the envelope for said device.

14. The method of making an electron discharge device comprising forming a hollow metal cylinder, forming a cavity resonator, forming a cup-shaped vitreous envelope portion, mounting contact members in said cup-shaped portion, supporting an insulator on said contact members, mounting a cathode and heating filament on said insulator, connecting said filament to a pair of said contact members, connecting said resonator to one end of said cylinder, and closing the other end of said cylinder by means of said cup-shaped portion.

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