

April 14, 1953

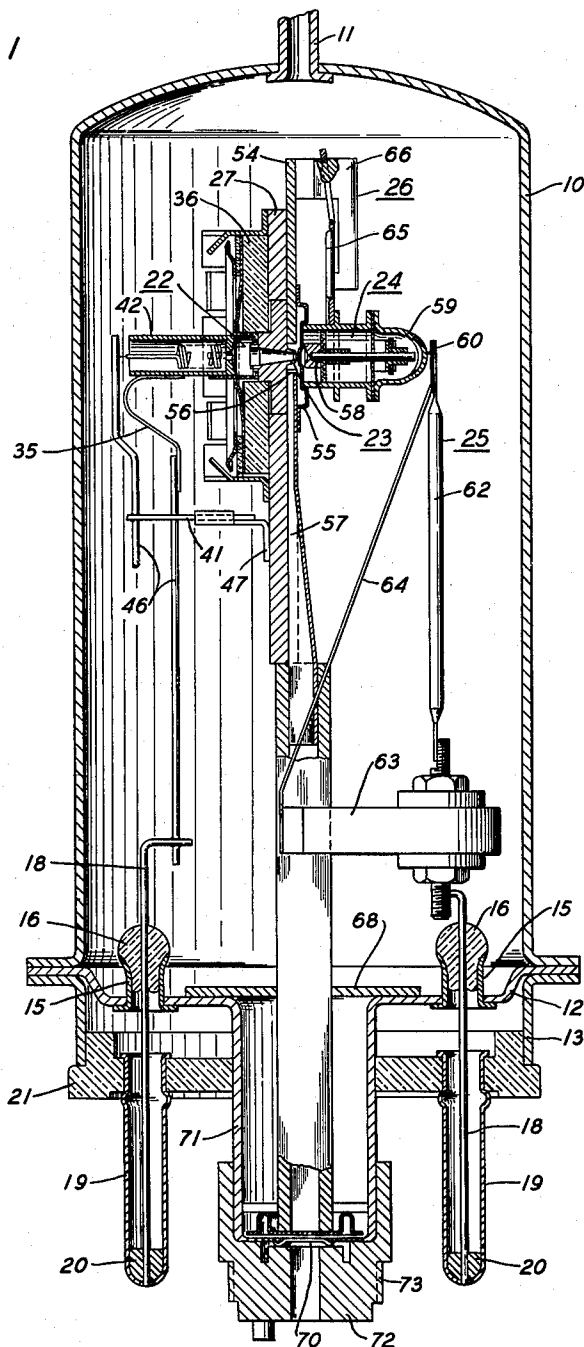
Filed Dec. 1, 1950

C. T. GODDARD
ELECTRON DISCHARGE DEVICE OF
THE CAVITY RESONATOR TYPE

2,635,207

2 SHEETS—SHEET 1

FIG. 1



INVENTOR
C. T. GODDARD
BY *[Signature]*

ATTORNEY

April 14, 1953

C. T. GODDARD
ELECTRON DISCHARGE DEVICE OF
THE CAVITY RESONATOR TYPE

2,635,207

Filed Dec. 1, 1950

2 SHEETS—SHEET 2

FIG. 2

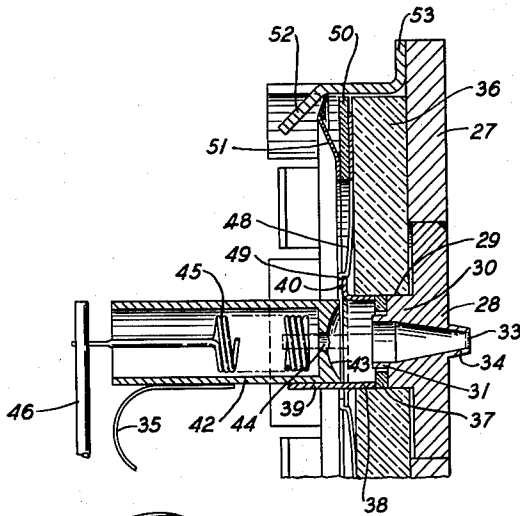
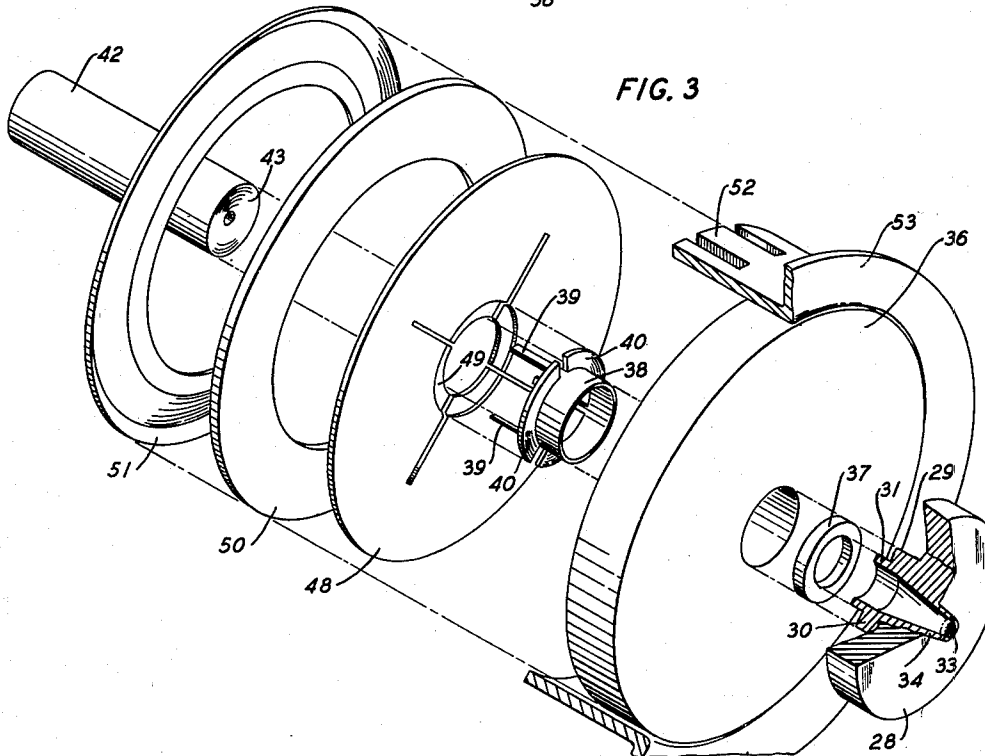


FIG. 3



INVENTOR
C. T. GODDARD

BY

[Signature]

ATTORNEY

UNITED STATES PATENT OFFICE

2,635,207

ELECTRON DISCHARGE DEVICE OF THE
CAVITY RESONATOR TYPE

Charles T. Goddard, Basking Ridge, N. J., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application December 1, 1950, Serial No. 198,612

8 Claims. (Cl. 315-5)

1

This invention relates to electron discharge devices and, more particularly, to reflex oscillators of the cavity resonator type.

The trend of design in such reflex oscillators has been consistently to smaller wavelengths. The attainment of efficient and satisfactory operation at extremely high frequencies and short wavelengths requires smaller dimensioned electrodes and very close spacings between the electrodes and between the electrodes and the other elements of the device. Further, satisfactory operation at extremely high frequencies requires extreme accuracy in the dimensioning and also in the alignment of the electrodes. Thus, each dimensional tolerance that is introduced into the device becomes a critical one.

The area through which the electrons pass from the cathode into the cavity resonator is particularly small, the diameter of the aperture in an illustrative device being of the order of .023 inch. In order that an advantageously high percentage of electrons emitted by the cathode may pass through this small area, the electrodes which comprise the cathode gun assembly must be accurately aligned and be positioned within very close requirements. This requires the critical spacing and alignment of the cathode surface, the beam electrode, and the focusing electrode. Any rotational inaccuracy, such as a tilt of even one degree, in the cathode or any displacement of the cathode or the beam electrode, such as of the order of .003 or .005 inch, from the axial alignment of the focusing electrode will considerably reduce the percentage of emitted electrons directed through the small aperture into the cavity resonator.

It is, therefore, one object of this invention that a very high percentage of electrons emitted from the cathode shall pass through the extremely small aperture required for very high frequency operation and shall enter into the cavity resonator.

A further object of this invention is to accurately align and position the electrodes and elements of the electron gun assembly required for devices intended for extremely high frequency operation.

A further object of this invention is to reduce the number of dimensional tolerances introduced into the alignment and positioning of the elements of the electron gun assembly and, more particularly, to reduce the number of tolerances that must be accurately kept on any one of these elements.

A still further object of this invention is to facilitate the assembling of the electron gun and, more particularly, to do so by eliminating the use of assembling jigs and the concomitant introduction of dimensional errors because of the tolerances inherent in the jigs themselves.

2

These and other objects of this invention are attained in one specific illustrative embodiment wherein the focusing electrode is provided with an accurately determined external diameter and a ridge internal to that diameter and extending further along the axis of the electrode. An insulating ring of precise thickness surrounds this ridge and fits loosely on the focusing electrode. A larger insulating member with an accurately determined inner diameter fits snugly over the accurately determined external diameter of the focusing electrode. A beam or beam forming electrode is provided with a plurality of thin fingers fitting directly onto the cathode sleeve to which the other portions of the cylindrical beam electrode are adjacent. The cathode sleeve diameter and the inner diameter of the cylindrical beam electrode are accurately determined. The beam electrode fits into the accurately determined inner ring of the larger insulator, the outer diameter of the beam electrode fitting snugly into the insulator ring. Spring means bear against the beam electrode and bias it towards the focusing electrode. In this embodiment, the various components of the electron gun assembly are thus all supported by each other in a single unit.

It is, therefore, one feature of this invention that each of the components of the electron gun assembly positions and aligns other components of the assembly without the use of external jiggling or aligning means.

It is a further feature of this invention that the required tolerances on each component part of the electron gun assembly are reduced to a minimum and, more particularly, that each part has only a single critical dimension, which may be accurately determined in the machining of the parts.

It is a further feature of this invention that the beam forming electrode is secured directly to the cathode by means of a plurality of thin fingers, the beam electrode thus supporting the cathode in the cathode gun assembly. Further, as the only thermal contact between the two is made by these fingers extending onto the cathode sleeve, the beam electrode can be maintained cooler than the cathode.

It is a further feature of this invention that all of the components of the electron gun assembly are supported together as a single unit by a single retaining means.

It is a still further feature of this invention that the components of the electron gun assembly are maintained in proper position by spring means.

A complete understanding of this invention and of the various features thereof may be gained from consideration of the following detailed description and the accompanying drawings, in which:

Fig. 1 is an elevational view of an electron discharge device of the reflex oscillator type in which is incorporated one specific illustrative embodiment of this invention;

Fig. 2 is an enlarged sectional view of the electron gun assembly of the device illustrated in Fig. 1; and

Fig. 3 is an exploded perspective view of the electron gun assembly of the embodiment of Fig. 1.

Referring now to the drawing the electron discharge device illustrated at Fig. 1 comprises a highly evacuated enclosing vessel including a metallic flanged cylindrical portion 10 having an exhaust tubulation 11 at the top thereof, a base member 12 and a skirt 13 both secured, as by welding, to the flange portion 10. The base member 12 has attached thereto and extending therethrough a plurality of metallic eyelets 15 in which are hermetically sealed beads 16 of a vitreous material. Lead-in conductors 18 extend through and are hermetically sealed to the beads 16, being connected to terminal pins 19 as by drops of solder 20. The terminal pins 19 are carried by an insulating disc 21, which may be of a phenolic condensation product or other insulating material known in the art and which is mounted by the skirt 13.

Mounted within the enclosing vessel are an electron gun assembly 22, more clearly seen in Figs. 2 and 3, a cavity resonator 23, a repeller assembly 24, a thermal tuner assembly 25, more fully described in my application Serial No. 198,611, filed December 1, 1951, and a spring assembly 26, also more fully described in my co-pending application.

The electron gun assembly 22 is supported from a mounting member 27 which has a central aperture therein in which is brazed the focusing electrode 28. The focusing electrode 28 may be formed integral with the mounting member but is advantageously separate therefrom to facilitate the accurate machining of the outer circumference 29 of a portion 30 extending behind the mounting member 27. The portion 30 has a circular ridge 31 which is the field-forming portion of the accelerating electrode extending further behind the mounting member 27 and away from the grid 33 across the nose 34 of the focusing electrode 28. A large insulator ring 36 has an accurately dimensioned internal diameter to fit closely onto the outer surface 29 of the focusing electrode portion 30. A small insulator ring 37 advantageously having an accurately determined thickness is positioned adjacent the circular ridge 31 and serves to insulate and space the focusing electrode 28 from a beam forming electrode 38 which also fits closely and accurately against the inner surface of the large insulator ring 36.

The beam electrode 38 is formed with a plurality of integral fingers 39 and intermediate flanges 40, the fingers fitting onto the accurately determined outer diameter of a cathode sleeve 42. The cathode sleeve 42 has a surface 43 at its one end facing the beam forming electrode 38 and the resonator cavity 23, the surface advantageously being concave and having an electron emissive coating thereon, as is known in the art. The surface 43 also may advantageously have a central aperture 44 therein to prevent the emission of electrons along the axis of the resonator, as is also well known in the art.

A heater element 45 is positioned within the cathode sleeve 42, both ends of the heater 45 being advantageously electrically connected, as by leads

46, to lead-in conductors 18 extending through the vitreous beads 16. The cathode is advantageously connected to a lead-in conductor 18 by a tab 35 and a lead 46. The leads 46 extend through a mica or other insulating plate 41, the plate being supported from the wave guide output line as by a nickel clip 47.

A flat spider spring 48 is positioned against the large insulator ring 36 and has an inner off-set portion 49 bearing against the flanges 40 of the beam electrode 38. A ring insulator 50 separates the finger spring 48 from a ring spring 51, both springs being locked in position by the bent fingers 52 of a retainer member 53 which is secured to the mounting member 27 and surrounds the large insulator ring 36.

The cavity resonator assembly 23 comprises a metallic cavity block member 54, a diaphragm 55 supporting a grid centrally and extending across an aperture in the cavity block member 54, an iris 56 of dimensions such that electromagnetic energy generated in the cavity resonator is optimally transmitted into a wave guide output line 57, and a repeller electrode 58 mounted within a repeller assembly 24. The repeller assembly 24 has a hemispherical end 59 adjacent which, but separated therefrom by a gap 60, is the tuner assembly 25. The tuner assembly 25 in turn comprises a thermally expansive strut 62 mounted from a base member 63 and a pair of straps 64 extending from either end of the base member 63 around the wave guide output line 57 to the remote end of the strut 62, thereby forming a triangular pyramid structure.

The spring assembly 26 comprises a flat spring 65 bearing against the repeller assembly 24 and a spring support 66. The operation of the tuner assembly 25, whereby, inter alia, the tuner characteristic substantially approaches the ideal characteristic for tuning, and prestressing of the diaphragm is avoided, and the various desirable features of the spring assembly 26 whereby, inter alia, the initial dimensions of the resonator cavity can be readily and accurately determined, are set forth in my above-mentioned application.

The wave guide output line 57 is supported from the base member 12 by a plate 68 having a central aperture therein through which the wave guide line 57 extends, the plate 68 being secured, as by brazing, to both the wave guide line 57 and the base 12. The wave guide line 57 thus serves as a central support by which the other elements of the device are mounted from the base of the vessel.

The wave guide line 57 has a thin glass window 70 serving as a vacuum barrier at its lower end, secured in a cup-shaped portion 71 of the base member 12. A cup-shaped coupling member 72 is advantageously secured, as by brazing, to the cup-shaped portion 71, and has threads 73 for joining to the standard wave guide fitting of the associated equipment.

In accordance with the several features of this invention, dimensional tolerances and eccentricities are maintained at a minimum thereby allowing an advantageously high percentage of electrons emitted from the cathode surface 43 to pass through the minute aperture in the nose 34 of the focusing electrode 28 or into the resonator cavity. This is accomplished in one way, in accordance with this invention, by eliminating the use of external jiggling or mounting of the elements. By making the parts self-aligning and self-supporting the possibilities of both rotational errors and axial inaccuracies in the posi-

5

tioning of the elements of the electron gun are substantially reduced. This can best be seen by reference to Fig. 3 and to one advantageous procedure of assembling the component parts of the unitary electron gun assembly, which will also demonstrate the facility with which the electron gun assembly can be commercially assembled under large scale production conditions.

The small insulator ring 37 is advantageously first dropped around the circular ridge 31 on the focusing electrode 28. The large insulator ring 36 may then be dropped around the portion 30 of the focusing electrode 28, the ring 36 fitting closely around the outer surface 29 of the portion 30. The beam electrode 38 is secured as by welding at the fingers to the cathode sleeve 42, the fingers 39 extending along the sleeve and supporting it. The main body of the beam electrode 38 itself is, however, advantageously not in contact with the sleeve 42, as explained more fully below. The beam electrode 38 to which the cathode sleeve 42 is attached is then advantageously placed into the central aperture in the large insulator ring 36, the inner edge of the beam electrode 38 resting on the small insulator ring 37 which accurately positions it from the focusing electrode 25. As this central aperture in the large insulator ring 36 has been accurately machined or otherwise dimensioned to fit closely over the surface 29 of the portion 30 of the focusing electrode 28, the beam electrode 38 is accurately positioned in axial alignment with the focusing electrode 28. The springs 48 and 51, with the intervening insulator ring 50, are then positioned in place, and the assembly locked by bending over a plurality of the fingers 52 of the retaining member 53.

It is to be particularly noted that not only is no external jiggling required to center or position any of the components of the gun assembly, but further that none of the elements are welded or otherwise permanently secured to another element, except that the beam electrode fingers 39 may advantageously be welded to the cathode sleeve 42. However, the fingers 39 are so short that any deformation from this cause is minimized. This obviates the appearance of any stresses in the assembly due to the welding, or other securing operations, which could be potential sources of relative motion of any of the gun components on subsequent heating of the cathode during operation of the device. It is to be recollected that, as discussed above, the amount of motion sufficient to cause a completed device to be rejected as unfit for commercial use, whether a motion causing a rotational tilting or an axial misalignment, is exceedingly small in very high frequency devices, such as this invention may advantageously be incorporated into. As the cost of these devices is relatively high, it is highly desirable that the possibility of rejection of a device as not meeting the required commercial standards for these causes be reduced.

The cathode sleeve 42, as discussed above, advantageously is held only by the fingers 39. As the cathode sleeve is thus held adjacent the emitting surface 43 by a plurality of fingers extending along the outer surface of the sleeve, the possibility of objectionable tilting of the cathode surface 43 is greatly reduced. Further by accurately dimensioning the outer surface of the cathode sleeve 42 and the inner surface of the beam electrode 38, i. e., of the electrode and

6

its fingers 39, axial alignment of the cathode sleeve 42 with the focusing electrode 28 is also assured.

The beam electrode 38 is advantageously of "Nilvar," a nickel-iron alloy, or other metallic material having a low thermal conductivity, while the spider spring 48 is advantageously of a nickel-chromium-iron alloy known as "Inconel X," stainless steel, or other metallic spring material having a higher thermal conductivity. By positioning the beam electrode 38 away from the cathode sleeve 42 to which it is only connected by the fingers 39, heat is conducted to the beam electrode 38 only through the fingers 39. However, because of the relative thermal characteristics of the beam electrode 38 and the spider spring 48 this heat seeps away through the beam electrode flanges 40 to the spring and to the insulator 36 so that the beam electrode 38 itself remains relatively cool.

An idea of the dimensions involved in a specific embodiment of this invention employable in a device operable at wavelengths of the order of 6 millimeters can be obtained from the following dimensions, which are, of course, only exemplary:

Inner diameter of ring 36	.142 ± .0005 inch
Thickness of ring 37	.019 ± .001 inch
Diameter of cathode sleeve 42	.125 ± .001 inch
Outer diameter of focusing electrode portion 30	.140 ± .0005 inch

In accordance with one desirable feature of this invention, as discussed above, the other dimensions of these elements are not critical, thereby making possible the accurately aligned electron gun assembly in accordance with this invention.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An electron gun assembly comprising a cylindrical cathode sleeve having an electron emitting surface at one end, a beam electrode having a plurality of fingers extending along said cathode sleeve adjacent said emitting surface, a focusing electrode, the outer surfaces of said beam electrode and said focusing electrode being aligned, insulating means closely fitting around said aligned outer surfaces and positioning said cathode sleeve, beam electrode, and focusing electrode in axial alignment, and means locking said electrodes and said insulating means in a unitary assembly.

2. An electron gun assembly comprising a cylindrical cathode sleeve having an electron emitting surface at one end, a beam electrode having a plurality of fingers extending along said cathode sleeve adjacent said emitting surface, a focusing electrode, the outer surfaces of said beam electrode and said focusing electrode being aligned, first insulating means closely fitting around said aligned outer surfaces and positioning said cathode sleeve, beam electrode, and focusing electrode in axial alignment, second insulating means coaxial with said beam and focusing electrodes and insulating said electrodes from each other, spring means biasing said beam electrode towards said focusing electrode, and means locking said spring means, said electrodes, and

said insulating means in a compact unitary assembly.

3. An electron gun assembly comprising: a cylindrical cathode sleeve having an electron emitting surface at one end, a beam electrode positioned adjacent said one end and coaxial with said sleeve, said beam electrode having a plurality of short fingers extending along said sleeve and comprising the only contact between said beam electrode and said sleeve, a focusing electrode coaxial with said beam electrode, the outer surfaces of said focusing electrode and said beam electrode being aligned, an insulator ring closely fitting around said aligned outer surfaces and positioning said cathode sleeve, beam electrode, and focusing electrode in axial alignment, and means locking said electrodes and said insulating means in a compact unitary assembly.

4. A electron discharge device comprising: a cylindrical cathode sleeve having an electron emitting surface at one end, a beam electrode positioned adjacent said one end and coaxial with said cathode sleeve, said beam electrode having a plurality of fingers extending along said sleeve and comprising the only contact between said beam electrode and said sleeve, a focusing electrode coaxial with said beam electrode, the outer surfaces of said focusing electrode and said beam electrode being aligned, a first insulator ring closely fitting around said aligned outer surfaces and positioning said cathode sleeve, beam electrode, and focusing electrode in axial alignment, a second insulator ring positioned within said first ring and substantially coaxial therewith, said second ring being between said beam and said focusing electrodes, spring means biasing said beam electrode towards said focusing electrode, and means locking said spring means, said electrodes, and said insulator rings in a compact unitary assembly.

5. An electron discharge device comprising a focusing electrode having a cylindrical rear portion, a circular ridge extending from said portion and coaxial therewith, a first insulator ring positioned around said ridge, a cylindrical beam electrode bearing against said first ring and having the same outer diameter as said portion, said beam electrode having a plurality of fingers extending therefrom and flanges intermediate said fingers, a cylindrical cathode sleeve adjacent said beam electrode, said cathode sleeve having an electron emitting surface positioned towards said focusing electrode, said fingers extending along said cathode sleeve, a second insulator ring closely encompassing said portion and said beam electrode and positioning said electrodes and said cathode sleeves in axial alignment, spring means bearing against said flanges and biasing said beam electrode towards said focusing electrode, and means locking said spring means, said electrodes, and said insulator rings in a compact unitary assembly, said last-mentioned means comprising a retainer member rigidly connected to said focusing electrode and having bent fingers exerting pressure upon said spring means.

6. An electron discharge device comprising a mounting member having an aperture therein, a focusing electrode positioned in said aperture and secured to said mounting member, said focusing electrode having a cylindrical portion extending behind said mounting member, a circular ridge coaxial with said cylindrical portion and extending therefrom, a first insulating ring positioned

around said ridge, a hollow cylindrical beam electrode bearing against said first insulator ring and coaxial with said cylindrical portion, the outer surfaces of said cylindrical portion and said beam electrode being aligned, a cylindrical cathode sleeve having an electron emissive surface adjacent said beam electrode, said beam electrode having a plurality of integral fingers extending along said cathode sleeve and integral flanges intermediate said fingers, a second insulator ring fitting closely around said aligned surfaces and positioning said cathode sleeve, said beam electrode, and said focusing electrode in accurate axial alignment, spring means bearing against said flanges and biasing said beam electrode towards said focusing electrode, and a cylindrical retaining member secured to said mounting member and encompassing said second insulator ring, said retaining member having fingers bent over and exerting pressure upon but insulated from said spring means.

7. An electron discharge device in accordance with claim 6 wherein said beam electrode fingers comprise the only thermal contact between said cathode sleeve and said beam electrode.

8. An electron discharge device comprising a mounting member having an aperture therein, a focusing electrode positioned in said aperture and secured to said mounting member, a cavity resonator positioned to one side of said mounting member, said focusing electrode having an aperture defining an entrance for electrons into said resonator, a cylindrical portion extending from said focusing electrode away from said resonator, said cylindrical portion having a circular ridge, a first insulating ring having an accurately determined thickness positioned loosely around said ridge, a hollow cylindrical beam electrode bearing against said first insulator ring and coaxial with said cylindrical portion, the outer surfaces of said cylindrical portion and said beam electrode being aligned, a cylindrical cathode sleeve having a concave electron emissive surface towards said resonator, said beam electrode having a plurality of short fingers integral therewith extending along said cathode sleeve and integral flanges intermediate said fingers, said fingers comprising the only thermal contact between said cathode sleeve and said beam electrode, a second insulator ring fitting closely around said aligned surfaces and positioning said cathode sleeve, said beam electrode, and said focusing electrode in accurate axial alignment, a spider spring bearing against said flanges and biasing said beam electrode towards said focusing electrode, a thin insulating ring adjacent said spider spring, a ring spring bearing against said thin insulator ring, and a cylindrical retaining member secured to said mounting member and encompassing said second insulator ring, said retaining member having fingers bent over and bearing against said ring spring.

CHARLES T. GODDARD.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,239,416	Ehrenberg	Apr. 22, 1941
2,414,785	Harrison et al.	Jan. 21, 1947
2,452,318	Nergaard	Oct. 26, 1948
2,513,296	Ekstrand et al.	July 4, 1950