

May 12, 1942.

C. A. BIELING

2,282,392

ELECTRON DISCHARGE DEVICE

Filed June 6, 1941

2 Sheets-Sheet 1

FIG. 2

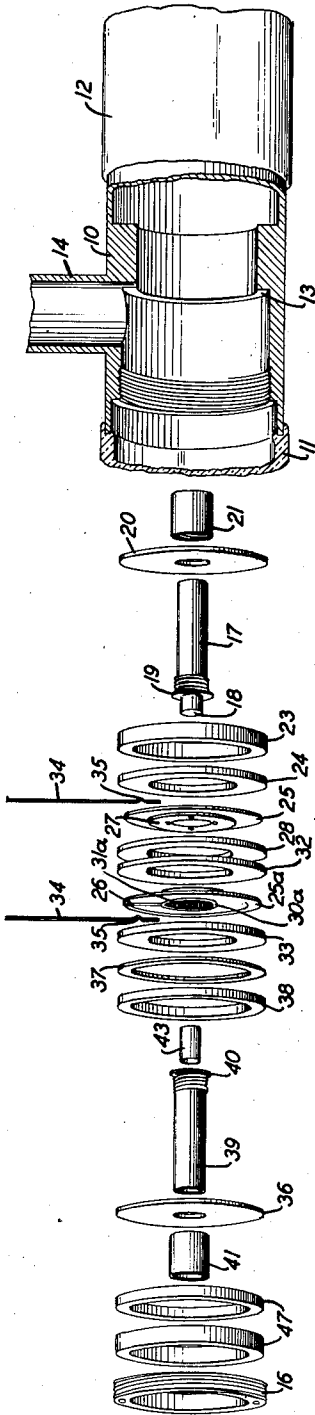


FIG. 3

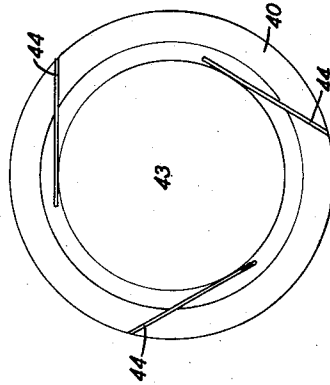
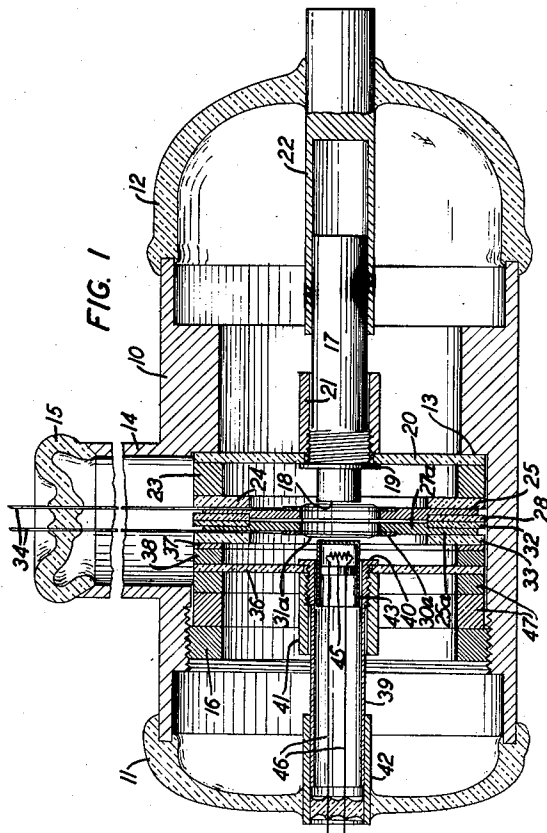


FIG. 1



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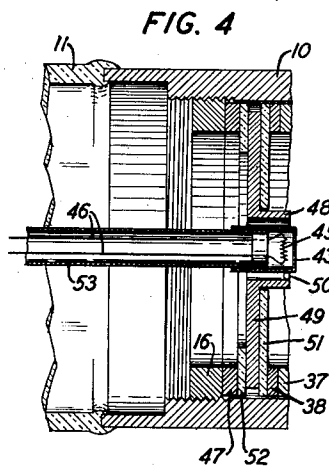
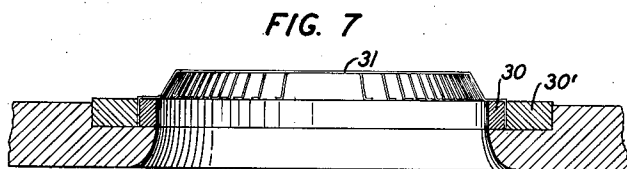
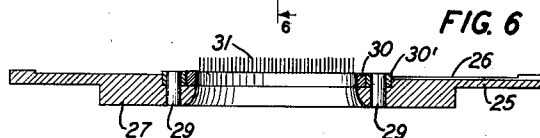
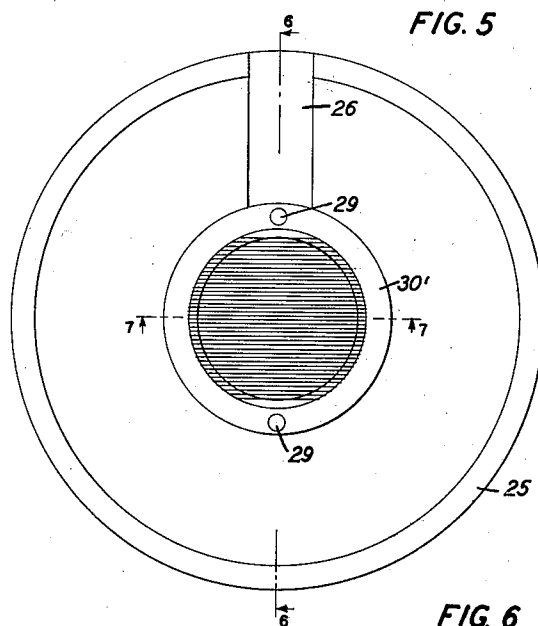
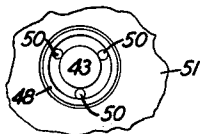


FIG. 4A



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ELECTRON DISCHARGE DEVICE

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13 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more particularly to such devices operable at frequencies corresponding to wavelengths in the centimeter range.

The operating characteristics of ultra-high frequency electron discharge devices of the type to which this invention pertains are dependent to a large extent upon the interelectrode spacings inasmuch as these spacings are largely determinative of the interelectrode impedances. In order that a particular device may have predetermined operating characteristics, it is necessary that the interelectrode spacings be accurately established during the fabrication of the device. Also, in order that the operating characteristics may be constant it is necessary that the interelectrode spacings be maintained constant during operation of the devices inasmuch as, the spacings being extremely small, changes of small absolute magnitudes therein result in relatively large variations in the interelectrode impedances and correspondingly large variations in the operating characteristics. The necessity of obtaining small interelectrode impedances requires the use of small electrodes which are difficult to space accurately and the dimensions of which may undergo relatively large variations with the temperature variations to which the electrodes are subjected during the outgassing treatment and the operation of the device.

One object of this invention is to maintain the spacing of electrodes in an electron discharge device substantially constant during the operation thereof.

More specifically, one object of this invention is to preserve the form of the electrodes and to maintain fixed the position of the effective portion or surface thereof while allowing expansion and contraction of the electrodes with temperature variations therein.

Another object of this invention is to enable the expeditious mounting of two or more electrodes in accurate, very small space relation.

A further object of this invention is to reduce heat losses by conduction from thermionic cathodes whereby an improved thermal efficiency for the cathode is realized.

In one illustrative embodiment of this invention, an electron discharge device operable as an amplifier at frequencies corresponding to wavelengths of the order of 15 centimeters comprises a cathode, an anode, a control grid and a screen grid, the several electrodes having substantially parallel effective surfaces in close space relation.

In accordance with one feature of this inven-

tion, the cathode or anode, or both, is so mounted that the effective surface thereof is fixed against displacement with temperature variations while the other portions thereof may expand and contract freely with temperature variations.

In accordance with another feature of this invention, the control grid and screen grid, or both, comprises a support and a plurality of wires having parallel linear portions lying in a common plane and is so constructed that the wires maintain their parallel coplanar relation despite temperature variations therein.

In accordance with a further feature of this invention, the several electrodes are mounted within a cylindrical member which positions the electrodes in coaxial relation and are spaced from one another by spacers of accurately predetermined thickness, the electrodes and spacers constituting a pile-up of elements within the cylindrical member and being locked in position within the cylindrical member by a single clamping or locking element.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is a side view mainly in section of a portion of an electron discharge device illustrative of one embodiment of this invention;

Fig. 2 is an exploded perspective view of the electrode assembly included in the device illustrated in Fig. 1;

Fig. 3 is an enlarged end view of the cathode and its support in the device shown in Fig. 1;

Fig. 4 is a detail view in section of a modification of the cathode assembly included in the device shown in Fig. 1;

Fig. 4A is a fragmentary end view of the cathode and the support therefor included in the assembly shown in Fig. 4;

Fig. 5 is an enlarged plan view of the grid assemblies included in the device shown in Fig. 1;

Fig. 6 is a view in section of the grid assembly taken along line 6—6 of Fig. 5; and

Fig. 7 is another view in section along line 7—7 of Fig. 5 of the grid assembly.

Referring now to the drawings, the electron discharge device illustrated in Figs. 1 and 2 is a tetrode especially suitable for use as an amplifier at ultra-high frequencies and comprises an evacuated enclosing vessel having an intermediate, cylindrical metallic portion 10, for example of copper, and vitreous end portions 11 and 12 hermetically sealed to opposite ends of the me-

tallic portion 10. The metallic portion 10 is provided with an annular internal seat or shoulder 13 and has an integral tubulation 14 hermetically sealed at its outer end by a vitreous cap or body 15.

Mounted within the metallic portion 10 and clamped against the seat or shoulder 13 by a ring 16 threaded to the portion 10 is a pile-up of elements including a cathode, a pair of grids and an anode mounted in coaxial relation, very closely spaced and insulated from one another and the metallic portion 10. The anode comprises a metallic rod 17 having a plane end face 18 and an integral collar 19 seated on an insulating washer or support 20, for example of mica or silica, in turn seated on the seat or shoulder 13, the anode being clamped centrally to the washer 20 by a lock member 21 threaded thereon, and the washer 20 fitting the internal wall of the portion 10 of the enclosing vessel to locate the anode coaxially within this portion. Leading-in connection to the anode may be established through a tubular conductor 22 slidably fitted on the anode rod 17 and sealed through the outer end of the vitreous portion 12 of the enclosing vessel.

Bearing against the washer or support 20 is a metallic spacing ring 23 which has bearing thereagainst, in turn, an annular insulating spacer 24, for example of mica or silica, of accurately predetermined thickness so as to position the screen grid assembly accurately in desired relation to the surface 18 of the anode.

As shown more clearly in Figs. 5, 6 and 7, the screen grid assembly includes an annular metallic support 25, for example of copper, having in one face thereof a radial recess 26 and having also a raised portion 27 which is fitted in a central aperture in an insulating support 28, for example of quartz or mica, fitted within the metallic portion 10 of the enclosing vessel. Seated in an annular recess in the support 25 and secured to the support, as by rivets 29, is an annular metallic member 30' in which there is fixed a metallic ring 30. Secured between the members 30 and 30' are a plurality of substantially U-shaped parallel, equally spaced wires 31. As shown in Fig. 2, the intermediate portions of the wires 31 are coplanar and parallel to the surface 18 of the anode and in immediate proximity thereto. For example, the spacing between these wires and the surface 18 may be of the order of .016 inch.

In order to maintain the position of the intermediate portions of the wires 31 substantially unaltered during the temperature cycles through which the wires pass during the outgassing treatment and operation of the device, in a particularly advantageous construction the wires 31 and annular members 30 and 30' are made of particular materials and the assembly is fabricated in a particular manner. Specifically, the wires 31 are made of a material having a higher temperature coefficient of expansion than the annular members 30 and 30' so that, relatively speaking, when the grid assembly undergoes temperature variations the annular members 30, 30' remain substantially fixed in form and dimensions. As specific illustrations, the wires 31 may be of nichrome and the annular members 30 and 30' may be of nickel or iron, or the wires may be of tungsten and the annular members may be of molybdenum.

In the fabrication of the grid structure, straight wires are secured at their ends and in parallel relation between the members 30 and 30'. The

annulus is then fixedly mounted, the assembly is heated and the wires are formed by a suitable die into the form shown in the drawings. The forming of the wires is carried out at a temperature higher than that to which the wires are heated during the outgassing treatment and operation of the device. Consequently, in the completed grid structure, the wires 31 are constantly under a slight tension and any expansion and contraction of the intermediate portions of the wires 31 during the outgassing treatment and operation of the device is substantially linear, in the direction of the length of the wires, so that these intermediate portions remain effectively in a common, fixed plane at all times.

Bearing against the insulating support 28 and fitted within the metallic portion 10 of the enclosing vessel is another insulating support 32, similar to the support 28, which mounts a control grid assembly in coaxial relation with the screen grid assembly. The control grid assembly is the same as the screen grid assembly, is fabricated in the manner described above and includes a support 25a having a radial slot 26a in one face thereof and having also a raised portion 27a fitted in the central aperture in the insulating support 32, an annular metallic member 30a seated in a recess in and secured to the support 25a, and a plurality of parallel, equally spaced, substantially U-shaped wires 31a secured at their ends to the annular member 30a.

The radial slots or recesses 26 and 26a extend at the same angle, for example a right angle, with respect to the respective wires 31 and 31a. Fitted in these recesses or slots and held therein by the insulating member 24 and a similar member 33 are metallic strip conductors 34 having bent portions 35 which provide sufficient friction between the conductors and the associated supports and insulating members engaged thereby to lock the conductors in position. The conductors are of the same width as the slots or recesses 26 and 26a so that when the conductors are aligned during the assembly of the device, the wires 31a of the control grid are positioned in parallel relation to the wires 31 of the screen grid. As shown in Fig. 1, the conductors 34 are sealed in the cap or closure 15.

Mounted opposite the control grid and coaxial therewith is a cathode structure which includes an annular insulating support 36, for example of fused silica, fitted within the metallic portion 10 of the enclosing vessel and accurately spaced a predetermined distance from the insulating member 33 by a pair of metallic spacers 37 and 38. Coaxially positioned with respect to the support 36 is a tubular metallic member or support 39 having a flange 40 bearing against the support 36, the member or support 39 being securely affixed to the support 36 by a lock member 41 threaded on the support 39 and bearing against the support 36. The support 36 is slidably engaged by a tubular conductor 42, similar to the conductor 22, which serves as the leading-in conductor for the cathode and is sealed to and extends through the vitreous portion 11 of the enclosing vessel.

The cathode structure includes also a metallic cup-shaped cathode member 43 the outer surface of the base of which is coated with a thermionic material and which surface is parallel and in immediate proximity to the intermediate portions of the wires 31a of the control grid. The spacing between this surface and these wires may be of the order of .008 inch. The cathode member 43

is positioned coaxially within the inner end of the support 39 by three thin wires 44, of a material having low heat conductivity, such as nichrome, arranged tangentially with respect to the cathode member and secured thereto and to the flange 40 of the support 39. Mounted within the cathode member 43 is a heater filament 45 having leading-in conductors 46 extending through the support 39 and conductor 42.

The cathode structure is fixed in position by metallic rings 47, one of which bears against the support 39, which rings are locked in position by the ring 16.

It will be noted that in the device described hereinabove the interelectrode spacings are maintained substantially constant during operation of the device so that the interelectrode impedances are maintained substantially constant and uniform operating characteristics are realized. The anode is rigidly mounted by the support 20 in proximity to the surface 18 so that the position of this surface is fixed. Expansion and contraction of the anode occurs substantially entirely between the support 20 and the vitreous portion 12, such action being permitted freely due to the sliding fit of the anode rod 17 in the tubular portion of the conductor 22. Similarly, the emissive surface of the cathode member 43 is fixed in position due to the rigid mounting of this member, by the wires 44, in proximity to the emissive surface thereof. Such expansion and contraction of the cathode as may occur during operation of the device takes place between the support 36 and the vitreous portion 11 of the enclosing vessel, this action being permitted freely by the sliding fit between the support 39 and the leading-in conductor 42. Because of the form and construction thereof, any expansion and contraction of the intermediate portions of the grid wires 31 and 31a occurs in the direction of the length of these portions so that the intermediate portions of the wires of each grid remain coplanar during operation of the device and the position of the common plane remains fixed. The several insulating washers and supports have a very low temperature coefficient of expansion and contraction and, hence, remain of substantially fixed dimensions during operation of the device.

It will be noted also that the physical connection between the cathode member 43 and the support 39, although rigid, is very small from a thermal standpoint, because of the thinness and material of the wires 44, so that little heat transfer by conduction occurs between the cathode member and the support. Hence, a high thermal efficiency for the cathode is obtained and, in addition, the support 39 is maintained at a fairly low temperature during the operation of the device.

Electrically, the cathode construction has at least two decided advantages. The support 39 and cathode member 43, it will be noted, have juxtaposed coaxial cylindrical portions of appreciable areas so that the capacitance therebetween is fairly high and, as a result, a low impedance path for high frequency currents is attained, thereby preventing permeation of high frequency currents to the heater system for the cathode. Also, the leading-in conductors 46 are within the leading-in system for the cathode so that these conductors are effectively outside of the high frequency field of the cathode to control grid circuit and the absorption of high fre-

quency energy thereby is extremely small whereby a high input efficiency is achieved.

It will be noted also that the ratio of the area of the emissive surface of the cathode to the total area of the inner end of the cathode structure is close to unity so that stray capacitances are minimized, whereby an optimum control or input efficiency is realized. Furthermore, it will be appreciated that the electrode system comprises two sections, one composed of the cathode and control grid and the other composed of the screen grid and anode, which are substantially mirror images of each other and which are coupled only by the electron stream so that the two sections together constitute a coaxial line section having very little discontinuity whereby constant operating characteristics and a high operating efficiency are obtained. Finally, it will be noted that the electrodes may be assembled expeditiously and the desired space relation thereof obtained accurately and in a facile manner.

In the cathode and support construction illustrated in Figs. 4 and 4A, the cathode member 43 is coaxially positioned within the cylindrical portion 48 of a metallic support 49 and is secured to this portion by three equally spaced thin wire elements 50 of low heat flow. The wire elements 50 may be, for example, of 3-mil tungsten welded to the cathode member 43 and the portion 48 of the support 49. The support is positioned between two insulating annuli 51 and 52, for example of quartz or silica, one of which bears against the metallic spacer ring 38 and the other of which has bearing thereagainst the metallic ring 47. Leading-in connection to the cathode may be established through a tubular metallic conductor 53 slidably fitted within the cathode member 43, the conductor 53 enclosing the leading-in conductors 46 for the heater filament 45. It will be noted that the cathode member 43 is rigidly mounted in position, by the wire elements 50, in immediate proximity to the emissive surface thereof, so that the position of this surface is fixed during operation of the device. Such expansion and contraction of the cathode member as may occur with temperature variations takes place to the left, in Fig. 4, of the emissive surface and is permitted freely by the sliding fit of the cathode member and the conductor 53. The heat loss from the cathode member due to conduction by way of the wires 50 obviously is extremely small so that a high thermal operating efficiency for the cathode is obtained.

After the assembly of the device and prior to its pumping and outgassing, the outer surface of the portion 16 is coated with a silver paste or is electroplated with silver. This procedure prevents the formation of metallic oxides at the elevated temperatures during pumping and provides good electrical contact to the portion 16 in cases where the metallic portion 16 is associated with an external circuit or ground.

Although specific embodiments of the invention have been shown and described, it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electrode for electron discharge devices comprising an apertured support member, and a plurality of wires secured to said support member at their ends and overlying the aperture

therein, each of said wires having an intermediate U-shaped portion including an elongated, linear central part and arms extending from the ends of said linear part and at angles thereto, the linear central parts of said wires being substantially parallel and coplanar.

2. An electrode for electron discharge devices in accordance with claim 1 wherein said wires are of a material having a higher temperature coefficient of expansion than said support member.

3. An electrode for electron discharge devices in accordance with claim 1 wherein said support member is of molybdenum and said wires are of tungsten.

4. An electrode for electron discharge devices in accordance with claim 1 wherein said support member is of nickel and said wires are of nichrome.

5. An electrode for electron discharge devices comprising an annular support, and a plurality of parallel wires each having an intermediate portion in the form of a U, the base of which is elongated and linear, said wires overlying the aperture in said support and having end portions fixed to said support.

6. The method of fabricating an electrode for electron discharge devices which comprises securing a plurality of wires at opposite ends and in parallel relation to a metallic support, heating the assembly thus formed to a temperature higher than that to which the electrode will be subjected when in use, and forming said wires while at said temperature into parallel elements having U-shaped sections the intermediate portions of which are substantially parallel to the plane of said support.

7. A cathode structure for electron discharge devices comprising a cup-shaped cathode member having an electron emissive surface, a rigid metallic support having a tubular portion encompassing and closely spaced from said cathode member, means mounting said support, and a plurality of thin wire elements of low heat conductivity securing said cathode member to said tubular portion.

8. A cathode structure for electron discharge devices comprising a support having a tubular portion, means rigidly mounting said support, a cup-shaped cathode member having a coating of thermionic material on the outer surface of the base thereof, said cathode extending within said support, being spaced therefrom and having said surface in proximity to one end thereof, a plurality of thin wires of metal having low heat conductivity secured to said cathode member adjacent said surface and to said support adjacent said one end thereof, heater means for said

cathode, and a leading-in conductor slidably engaging said support.

9. A cathode structure for electron discharge devices in accordance with claim 8 wherein said wires extend tangentially from said cathode member.

10. An electron discharge device comprising an enclosing vessel having an intermediate portion and opposite end portions, a cathode and an anode within said vessel and having opposed substantially parallel faces, a leading-in system for said anode including a pair of slidably fitted conductors one of which is sealed in one of said end portions and the other of which extends from said anode and is integral therewith, rigid means fixing the face of said anode against movement, a leading-in system for said cathode including a pair of slidably fitted conductors one of which is sealed to the other of said end portions and the other of which extends from adjacent said cathode, means rigidly securing said cathode to the other of said cathode leading-in conductors, and means fixing said other cathode leading-in conductor against displacement at the end thereof nearest said cathode.

11. An electron discharge device comprising a hollow cylindrical member, a plurality of electrodes within said member, supports for said electrodes secured thereto and extending transversely of and slidably fitted in said cylindrical member, spacer members between said supports, and means locking said supports and spacer members in said cylindrical member.

12. An electron discharge device comprising an enclosing vessel including a cylindrical metallic portion having a seating surface therein, a cathode, anode and grid within said vessel, annular supports for each of said cathode, anode and grid affixed thereto and slidably fitted in said cylindrical portion, spacer members between said supports and slidably fitted in said cylindrical portion, said supports and spacer members constituting a pile-up mounted on said seating surface, and a clamping ring fixed to said cylindrical portion and locking said pile-up against said seating surface.

13. An electron discharge device comprising a cathode, an anode, a pair of grid electrodes between said cathode and said anode, each of said grid electrodes comprising a support having a slot in one face thereof and a plurality of parallel wires affixed to the support, means spacing said grid electrodes in parallel relation, a pair of leading-in conductors each of which is fitted in one of said slots, and means fixing said conductors in relation to each other.

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