Feb. 12, 1935. G. M. ROSE, JR 1,991,174

ELECTRON DISCHARGE DEVICE

Filed June 24, 1933 2 Sheets-Sheet 1

Fig. 1.

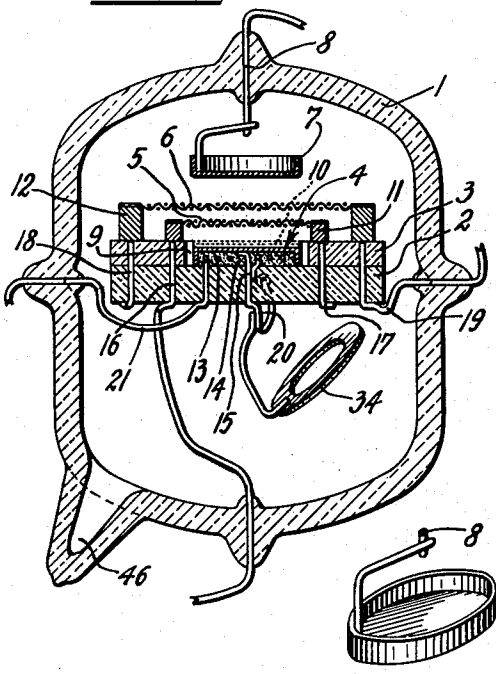
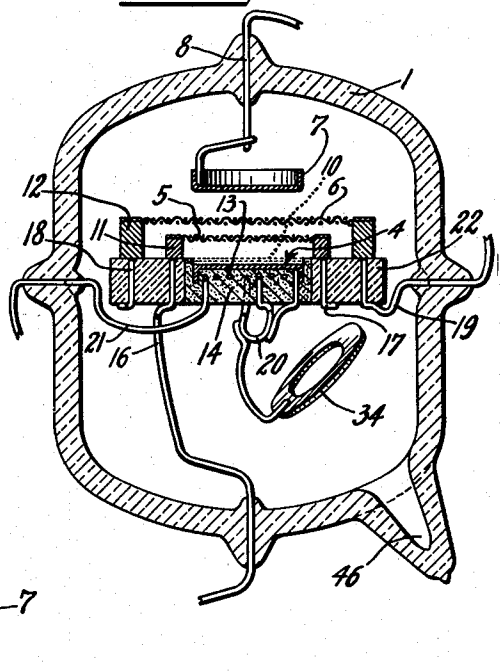


Fig. 2.



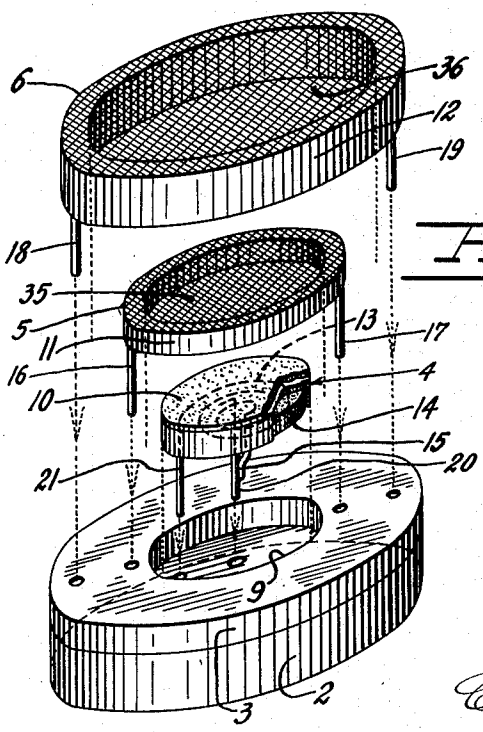


Fig. 4.

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Fig. 3.

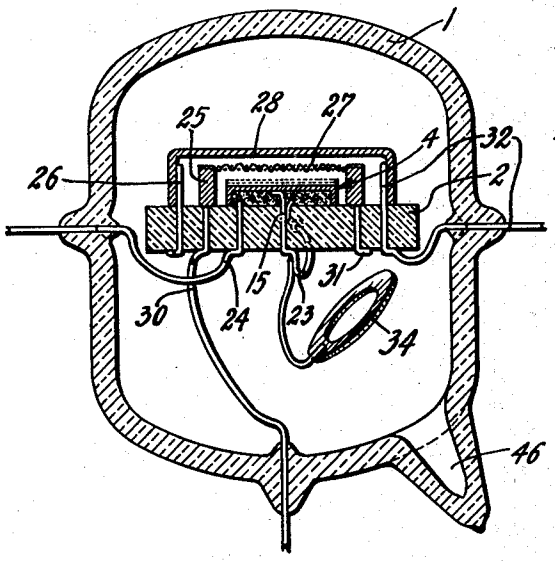


Fig. 5.

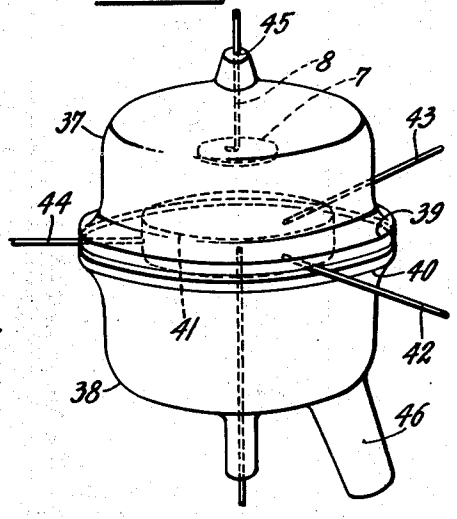
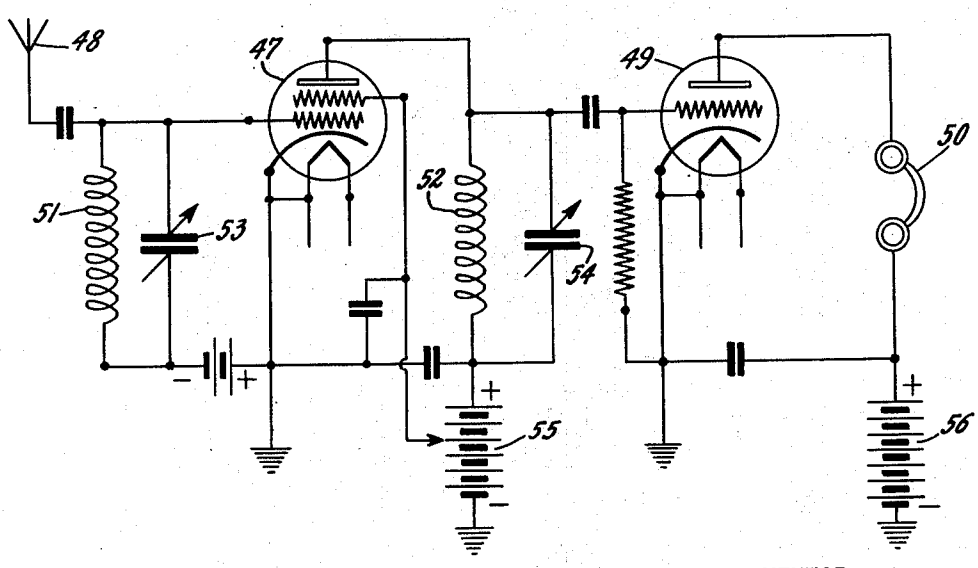


Fig. 6.



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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

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Application June 24, 1933, Serial No. 677,366

18 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices, and more particularly to electron discharge tubes useful at ultra high frequencies and capable of use in conventional circuits for radio reception at wave lengths of less than one meter.

It has been found that the wave lengths which can be used in radio communication with the conventional types and sizes of receiving tubes and circuits are limited by the tubes to about ten meters. By changes and modification in the tubes it is possible to receive somewhat shorter waves, but the limit of improvement by such changes is reached at about three to five meters wave length, due to various characteristics of the conventional tubes. For ultra short waves of a length less than one meter, special methods, involving the use of types of tubes and circuits other than the conventional types, have been used. These special methods, which make use of parallel wire tuning means and of oscillations, such as the Barkhausen-Kurz oscillations, developed within the tube, are, in general, operative at ultra high frequency and at wave lengths as short as thirty centimeters, but have, in comparison with conventional apparatus such as is used for longer waves, a number of serious disadvantages. In general these methods employ only one tube or one stage at the ultra high frequency, and carry out the amplification at an intermediate or low frequency. From the standpoint of practical use most of these methods are wasteful of plate power, are limited in sensitivity, as no amplification can be had ahead of the detector, and require high power and voltage to produce oscillations.

One object of my invention is to provide an electron discharge tube which may be used in conventional type circuits to receive radio waves having a length less than one meter.

Another object of my invention is to provide an electron discharge tube which compares favorably with a conventional tube in electrical characteristics, although having much less interelectrode capacitance and lead inductance than the conventional tube. A further object is to provide an electron discharge tube in which the overall dimensions and interelectrode spacing are much smaller than is feasible in tubes constructed in the usual way.

In the conventional receiving tube the inductances and capacitances inside the bulb are those inherent in the tube leads and electrodes. If such a tube is connected in a simple tuned radio frequency amplifier circuit, and the wave length is reduced by reducing the external inductance and capacitance, the external circuit becomes a smaller part of the total, with a loss in available amplified signal, until, with very short waves and at the limit, the plate lead inductance and plate to ground capacitance form a tuned circuit alone, and no amplified signal is available. To obtain useful amplification with such short waves I make the dimensions of the tube proportional to the wave length, keeping the linear physical dimensions in a constant ratio to each other to maintain the plate current, amplification factor, and transconductance constant, regardless of the magnitude of the linear dimensions, and provide a simple and sturdy tube structure which has very short leads with very little inductance and in which interelectrode spacings of the order of a few thousandths of an inch are accurately maintained, whereby the internal inductance and capacitance are greatly reduced.

My invention provides a simple, sturdy, and efficient type of vacuum tube which will operate in conventional types of circuits to receive radio signals of wave lengths below one meter and enable the advantages of the simplicity of such conventional circuits to be realized in the reception of ultra short waves.

An illustrative embodiment of my invention is an ultra short wave screen grid tube less than three quarters of an inch in diameter, with parallel plane electrodes correspondingly small in size and an interelectrode spacing of only a few thousandths of an inch. Such tubes, and similar tubes made in accordance with my invention may be used in conventional circuits as amplifiers, detectors, oscillators, or rectifiers at ultra high frequencies. Although the tube structure is particularly useful in short wave tubes having small electrodes, short leads, and very small interelectrode spacing, it has advantages in larger tubes, particularly where accurate interelectrode spacing and compact and sturdy construction are desirable, and is not limited to short wave tubes or to tubes of very small physical dimensions.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but my invention itself will best be understood from the following description taken with the accompanying drawings, in which

Figure 1 is a cross-sectional view of a screen grid tube made in accordance with this invention.

Figure 2 is a cross-sectional view of a modification of the tube in Figure 1.

Figure 3 is a cross-sectional view of a triode tube of this invention.

Figure 4 is an exploded view of the electrode assembly of a screen grid tube.

Figure 5 is a perspective view of the twin bell-shaped bulb before sealing.

Figure 6 is a circuit diagram of a conventional receiver employing two tubes of the present invention.

In all of the above figures the tube elements are shown greatly enlarged for sake of clearness and like reference characters have been used to designate identical elements.

Referring now to Figure 1, the electrode assembly is enclosed by the glass bulb 1. Insulator disks 2 and 3 are used to support the indirectly heated cup shaped cathode 4 and grids 5 and 6. The cup shaped anode 7 is supported by the lead wire 8 which is sealed in the glass bulb 1. The insulator disk 3 has a center hole, indicated at 9, in which the cathode 4 is so positioned that its top oxide coated emitting surface 10 lies flush with the top or grid supporting surface of the disk 3. On this top surface rest the annular metal frames or supports 11 and 12 of the grids 5 and 6 respectively. The thickness of the support 12 is sufficiently greater than the thickness of the support 11 to give the desired spacing between the grids 5 and 6. The thickness of the support 11 is chosen to give the correct spacing from the top or electron emitting surface of the cathode 4. The cathode 4 is heated by means of a spiral shaped heater represented by the circles 13. This heater is embedded in a mass of insulating material 14 which serves the purpose of confining the heat within the cathode and also for supporting the spiral heater. The cathode 4 is electrically connected to one leg of the heater 13 as indicated at point 15 but it may easily be brought out to a separate connection if desired. The grids 5 and 6 are maintained in their correct position by means of wires 16, 17, and 18, 19, respectively. These wires extend through small holes formed in the disks 2 and 3. Wires 17 and 18 are bent under the bottom of the disk 2 to hold the grids in place, while the grid lead wires 16 and 19 extend outward through the glass bulb 1 and serve to electrically connect the grids 5 and 6 respectively, with the external circuits. Cathode lead wires 20 and 21 are arranged in a similar manner to electrically connect the heater 13 and the cathode 4 to external circuits. No stem or press is used with this type of construction, the lead wires supporting the electrode assembly and being brought out as indicated at various points around the center portion of the bulb 1. The tube is exhausted in any well known manner, through the drawn out portion 46 and residual gases are cleaned up by "flashing" with a high frequency induction coil the getter which is painted on the metal ring 34.

The tube illustrated in Figure 2 is similar to that of Figure 1 described just above but distinguishes from it in some particulars. One insulating support disk is used instead of two and the cup shaped cathode is positioned within a center hole in this disk. The cathode in this case, as contrasted with that in Figure 1, is held in position by means of fused insulating material. In one practical example the insulator disk 22 has a hole drilled or punched out of its center portion and the cathode 4 is inserted into this hole to such an extent that its top oxide coated surface 10 is flush with the top surface of the disk 22. After insertion of the cathode the bottom part of this center hole and also the side spaces are filled in with insulating material as indicated by reference character 14. This insulating material is the same as that used inside the cathode 4 to hold the heater as described above in connection with Figure 1. An alternate manner of mounting the cathode 4 would be to punch out or drill a center hole in the disk 22 only to the depth of the cathode 4 and simply sit the cathode 4 in this recessed portion which has small holes drilled all the way through the disk 22 for the lead wires. The rest of the structure of Figure 2 as well as the method of manufacture is exactly like that of Figure 1 described above and, therefore, will not be described in detail here. Since the spacing between screen grid and anode in the screen grid tube is not critical the anode may be mounted in any suitable manner such as shown in Figures 1 and 2 but if desired it may be easily mounted on the insulator disk similar to the grid mounting.

The tube illustrated in Figure 3 distinguishes from those shown in Figures 1 and 2 in two main respects, namely, it is a triode construction instead of a screen grid tube and also employs different means for mounting the various elements. In this tube the single insulator supporting disk is like disk 2 shown in Figure 1, that is, it has no center hole formed for the cathode. In this construction the cathode 4 is mounted on top of the disk 2 and is held in place by means of the lead wires 23 and 24. Here also the cathode is connected electrically to one leg of the heater for convenience sake. The ring shaped grid supports 11 and 12 of Figure 1 would not be desirable for the tube of Figure 3 because they would be too thick and heavy since they would necessarily have a thickness greater than the height of the cathode 4. To obviate this difficulty a thin wall metal cylinder 25 is employed for supporting and spacing the grid 27 from the cathode 4 and from the anode 28. This cylinder rests on the top surface of the disk 2 and is maintained in its proper position by means of wires 30 and 31. The lead wire 30 electrically connects the grid 27 to the external circuit and the lead wire 32 electrically connects the anode 28 to the external circuit. The anode 28 is maintained in its proper position by means of lead wires 26 and 32. The interelectrode spacing in this construction is, of course, determined by the height of the cylinder 25 and the anode 28. It is obvious that this manner of supporting the electrodes, as well as the one already described above, is not limited to triode or screen grid types of tubes but is equally well adaptable to other multi-grid tubes.

Figure 4 represents an exploded view of the electrode assembly of a screen grid tube such as that shown in Figure 1. This figure 4 is intended to show the actual general appearance of the different electrodes which have been embodied in tubes made and successfully operated in accordance with this invention. Since these elements have been specifically described above in connection with preceding figures they will not be described here in detail; the main object here is to give a clear picture of the actual appearance of the elements. The bottom supporting disk of insulating material is designated by numeral 2. The cathode supporting member is represented by the disk 3 which rests upon the disk 2, supra. As stated above in connection with Figure 1 the disk 3 has a center hole 9 in which the cathode 4 is normally located. Within the mass of insulating material 14 is embedded the spiral shaped heater 13. The top surface of the cathode 4 is

covered with a layer of electron emitting material 10. The first grid, which in this tube is used as the control grid, designated by the reference character 5, comprises an annular metal supporting frame 11 and a circular layer of wire mesh 35 welded to the frame 11. The second or screen grid 6 comprises an annular metal supporting frame 12 and a circular layer of wire mesh 36 welded to the top of the frame 12. The anode 7 is a metal cup shaped electrode which may be identical in size and shape with that of the cup shaped cathode 4. The arrowed dotted lines indicate the necessary movement of the electrodes to locate them in their normal respective positions. For purposes of clearer illustration the holes in the disk 3, for receiving the lead wires from the grids 5 and 6, are shown adjacent each other but for optimum mechanical strength the outside holes are 90 degrees removed from the inside holes.

In Figure 5 is shown a perspective view of the bulb and electrode assembly before the sealing-in operation has been performed. The two separate "hat-shaped" parts 37 and 38 have flared portions 39 and 40 respectively. Before sealing in, the electrode assembly 41 represented here only diagrammatically is positioned by means of the lead wires 42, 43, and 44 which rest on the flared rim 40. The top half of the bulb 37, having the anode 7 suspended from the lead wire 8 sealed in the bulb at the point 45, is placed over the lead wires 42, 43, and 44 in registry with the rim 40. Rotating fires are applied to the flared rims 39 and 40 which cause the glass to flow and make an air tight seal between the two halves of the bulb 37 and 38. The lead wires will then, of course, be firmly fixed at different points around the center section of the bulb. The bulb is exhausted as stated above, through the tube 46.

As stated hereinbefore, tubes made in accordance with this invention may be used in any type of conventional circuit and will operate in accordance with well known principles. A representative well known type of tuned radio frequency circuit in which the tubes of this invention have been found to operate satisfactorily is illustrated in Figure 6. The screen grid tube designated by the numeral 47 may have the construction shown in Figure 1, and it operates as a radio frequency amplifier of the signals received over the antenna 48. The triode tube designated by the numeral 49, may have the construction shown in Figure 3, and it operates as a detector of the amplified radio frequency signals received from the tube 47. The amplified and detected signals would be audible in the head phones 50. The inductances 51 and 52, the tuning condensers 53 and 54, and the batteries 55 and 56 as well as the other associated parts are all of well known type. The triode and screen grid tubes of this invention have been used satisfactorily in multi stage receivers.

Since tubes of conventional size operate fairly well at wave lengths of five meters, tubes for 50 centimeter waves have been made in accordance with my invention with dimensions about one-tenth the dimensions of the conventional tubes, and with interelectrode spacings of the order of five thousandths of an inch. The cathodes were coated with the usual mixture of barium and strontium oxides, and the grids were made of the finest wire netting obtainable, about 400 mesh per square inch. The grid support rings 11 and 12 were made with a high degree of accuracy as to thickness, so that the grids were positioned and spaced with great precision. For example, in some cases the grid was put in a die or jig and the support ring pressed to exact thickness. The static electrical characteristics of a triode tube so made are directly comparable with those of the usual triode. For example, at a plate voltage of 67.5 volts and grid bias of 2 volts negative, the transconductance is 1550 microhms, the amplification factor 15, and plate resistance 9500 ohms. The interelectrode capacitances are exceedingly small, and are of the following order of magnitude; grid to cathode 0.7 mmf; plate to cathode 0.07 mmf; and plate to grid 0.8 mmf.

These tubes operated well in an inductive feedback oscillator whose inductance consisted of several turns of small copper wire wound in a helix about one-eighth of an inch in diameter and tuned by the tube interelectrode capacitances. With a coil of six turns very stable oscillations at 65 centimeters were produced, and with a coil of one turn oscillations of about 30 centimeters could be sustained with 115 volts on the plate and a plate current of about 3 milliamperes.

While a number of specific embodiments of the invention have been shown and described, it is to be understood that various other modifications and changes come within the purview of this invention the scope of which is limited only by the appended claims.

What is claimed is:

1. An electron discharge tube comprising, a flat cathode, a grid, and a plate in planes parallel to said cathode and of a diameter not greater than two hundred mils and an inter-electrode spacing between adjacent electrodes not exceeding ten mils.

2. An electron discharge tube comprising, a flat cathode, a flat grid, and a flat plate mounted in planes parallel to said cathode and with an inter-electrode spacing not greater than five mils and an electrode area not greater than three tenths of a square inch.

3. An electron discharge tube comprising, a cathode having a plane surface of high electron emissivity, an insulator with a plane surface parallel to and adjacent the edge of said cathode surface, a plate having a flat surface parallel to said cathode surface, a metal spacer ring surrounding and concentric with said cathode surface with one edge adjoining said plane surface of said insulator, and grid wires secured to the edge of said spacer ring and extending across said ring between said plate and said cathode in a plane parallel to said cathode.

4. In an electron discharge tube, an electrode assembly comprising a flat disk of insulation, a thermionic cathode secured to said disk and having a flat electron emitting portion in a plane parallel to the plane of the surface of said disk, a plate electrode having a flat portion parallel to said flat electron emitting portion of said cathode, and a grid electrode comprising an annular metal frame with one edge resting on and supported by said insulating disk, and a plurality of parallel conductors supported on the opposite edge of said frame and extending across said frame between said plate and said cathode and parallel to said flat portion of said cathode.

5. In an electron discharge tube, an electrode assembly comprising an insulating block having a flat annular surface, a thermionic cathode comprising a flat electron emitting disk mounted on said block concentric with said annular surface and in a plane parallel to the plane of said annular surface of said block, a plate electrode having a flat surface parallel to the plane of said annu-

lar surface of said block, a grid electrode comprising an annular metal frame concentric with said cathode and having one edge positioned on said annular surface of said block, and a plurality of straight conductors extending over the other edge of said frame and across said frame between and parallel to said cathode and said plate electrode.

6. An electron discharge device comprising, a sealed envelope enclosing an insulating disc, a disc cathode mounted on and concentric with said insulating disc, a grid electrode comprising an annular metal frame mounted on said disc concentric with said cathode and having grid wires extending over the edge of said frame and across said frame, a plate parallel to said cathode, and leads for said electrodes extending through the wall of said bulb.

7. An electron discharge tube comprising, a cathode, an anode, a flat insulator disk, a grid electrode comprising an annular metal frame mounted with one edge resting on said disk of insulation and concentric with said cathode, grid wires secured to the other edge of said frame and extending parallel to said cathode, and a conductor extending through said insulator disk and secured to said annular frame to hold said frame in place on said disk.

8. An electron discharge tube comprising, a cup shaped cathode having a flat disk surface capable of high electron emissivity, an insulator having a flat grid supporting surface parallel to the plane of said cathode surface and outside said cathode surface, a cup shaped anode similar in construction to said cathode and having its flat bottom surface positioned parallel to said flat surface of said cathode, and a plane disk shaped mesh grid electrode comprising a metal ring with one edge resting on said grid supporting surface of said insulator and conductors on the other edge extending between and parallel to said cathode and said anode.

9. An electron discharge tube comprising, a disk of insulating material, a cup shaped cathode positioned within a center hole in said disk, a cup shaped anode concentric with and surrounding said cathode and supported by said insulator disk, and at least one annular shaped grid electrode supported by said disk parallel to said cathode and said anode.

10. An electron discharge tube comprising, a disk of insulating material, a cup shaped cathode positioned on said disk, a cup shaped anode mounted concentric with said cathode and resting on said insulator disk, and a grid electrode mounted on a thin wall metal cylinder, said cylinder being concentric with said cathode and resting on said disk of insulating material.

11. An electron discharge tube comprising, two flat disks of insulating material one of said disks being solid and acting as a support for the second disk, said second disk having a center hole, a cup shaped cathode positioned within the center hole of said second disk in such a manner that its flat top electron emitting surface is flush with the top flat surface of said second disk, a plurality of disk shaped grid electrodes having annular shaped frames supported by said insulator disks in parallelism with said cathode, the spacing between the different electrodes being determined by the difference in thickness of the annular shaped grid frames, and a cup shaped anode similar in construction to said cathode positioned on the side of said grids remote from said cathode and parallel to said electron emitting surface of said cathode.

12. An electron discharge tube capable of amplifying radio signals of wave lengths less than one meter comprising, a glass envelope, an insulator disk, an indirectly heated cathode supported by said disk, at least one plane grid electrode having a frame and being supported by said disk, said grid being parallel to and spaced from said disk by the thickness of the frame upon which said grid is formed, and an anode having a plane surface positioned parallel to said disk.

13. In an electron discharge tube a cathode structure comprising, a disk of insulating material, a cup shaped cathode positioned within said disk so that its top flat electron emitting surface is flush with the top surface of said disk, a heating element supported within said cathode by means of fused insulating material contained therein, and current conductors attached to said cathode and said heating element, said conductors extending through the insulating material in said cathode.

14. An electron discharge tube capable of detecting radio signals having wave lengths less than one meter comprising, a flat surfaced supporting disk of insulating material, an indirectly heated cathode supported by said disk and having an oxide coated electron emitting surface positioned parallel to the flat surface of said disk, two annular metal supporting frames of different diameters and differing in thickness in a direction normal to the plane of said frames and each mounted with one edge adjoining said disc, and grid wires secured to the other edge of each of said frames to extend across each frame to form two plane parallel grids positioned parallel to said cathode emitting surface and separated from each other by a space the magnitude of which depends upon the thickness of the supporting frames on which said grids are mounted, and a plane surface anode positioned parallel to said grid electrodes.

15. An electron discharge device comprising an anode, an insulating support having a grid supporting surface, a cathode mounted on said support, a control grid and a screen grid mounted between said anode and said cathode, one of said grids comprising an annular metal ring mounted with one edge resting on said grid supporting surface of said insulating support, and conducting wires secured to the other edge of said ring to extend parallel to the surface of said cathode.

16. An electron discharge tube comprising a glass envelope having an outwardly extending circumferential flange, an electrode assembly in said envelope comprising a plane anode, an insulating disc parallel to the plane of said flange, a plane cathode and a plane parallel grid, said cathode and said grid being supported on said disc parallel to said anode, three stiff lead wires secured to said insulating disc and extending radially outward through and embedded in said flange at widely separated points, said lead wires constituting the electrical connections for said cathode and grid and engaging said disc near its rim at three points spaced over at least half of said disc to prevent tilting of said disc and to constitute its sole support.

17. An electron discharge tube comprising a cylindrical glass envelope having a transverse circumferential flange, an electrode assembly in said envelope comprising a thermionic cathode and a cooperating electrode, at least three rigid conductors hermetically sealed into and extending

through said flange radially at widely separated points on the circumference of said flange, two of said conductors being connected to said cathode and the third to said cooperating electrode, and a disc of insulation mounted on and supported solely by the inner ends of said conductors to extend transversely of said envelope adjacent said flange, said electrodes being mounted on and supported solely by said disc.

18. An electron discharge tube comprising a cylindrical glass envelope having a transverse circumferential flange, an electrode assembly in said envelope comprising an insulating disc extending transversely of said envelope in a plane parallel to the plane of said flange, a thermionic cathode and cooperating cold electrodes mounted on said disc, and rigid conductors hermetically sealed into and extending through said flange into said envelope with their inner ends secured to said disc at points spaced apart enough to prevent tilting of said disc.

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