

Sept. 3, 1946.

G. R. KILGORE ET AL
ELECTRON DISCHARGE DEVICE

2,407,163

Filed July 28, 1943

2 Sheets-Sheet 1

Fig. 1.

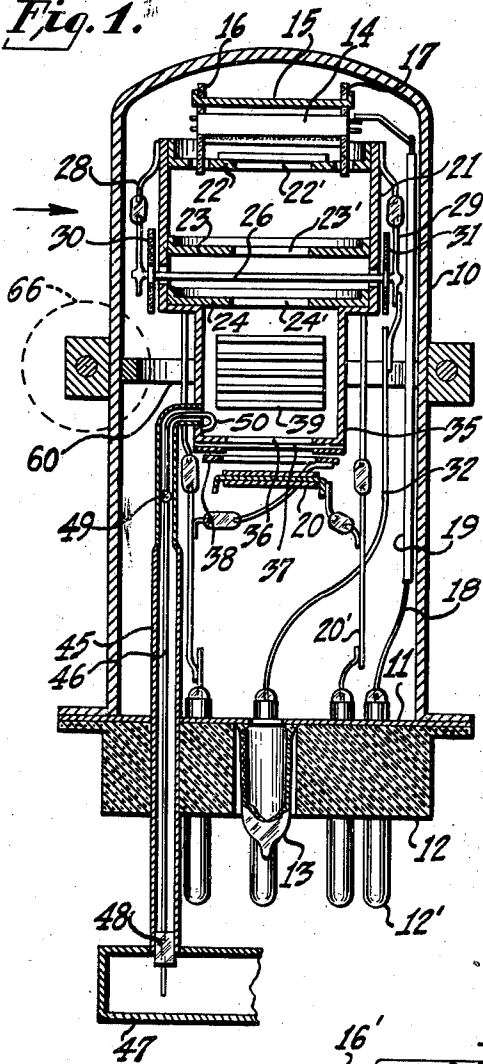


Fig. 2.

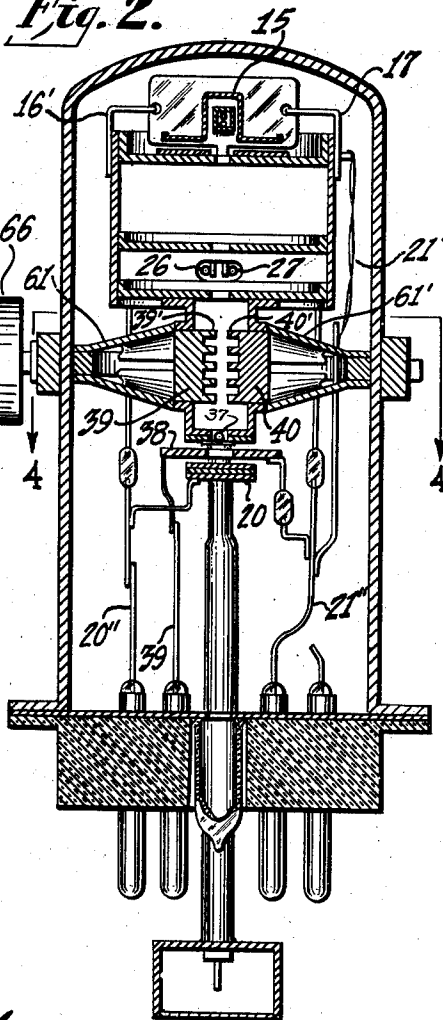
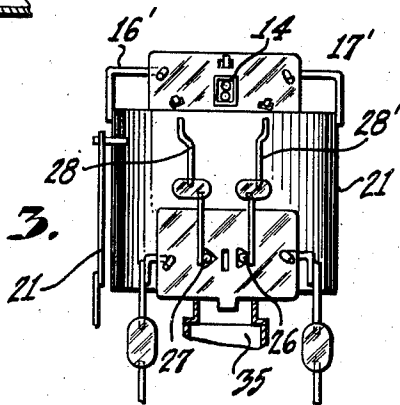


Fig. 3.



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Fig. 4.

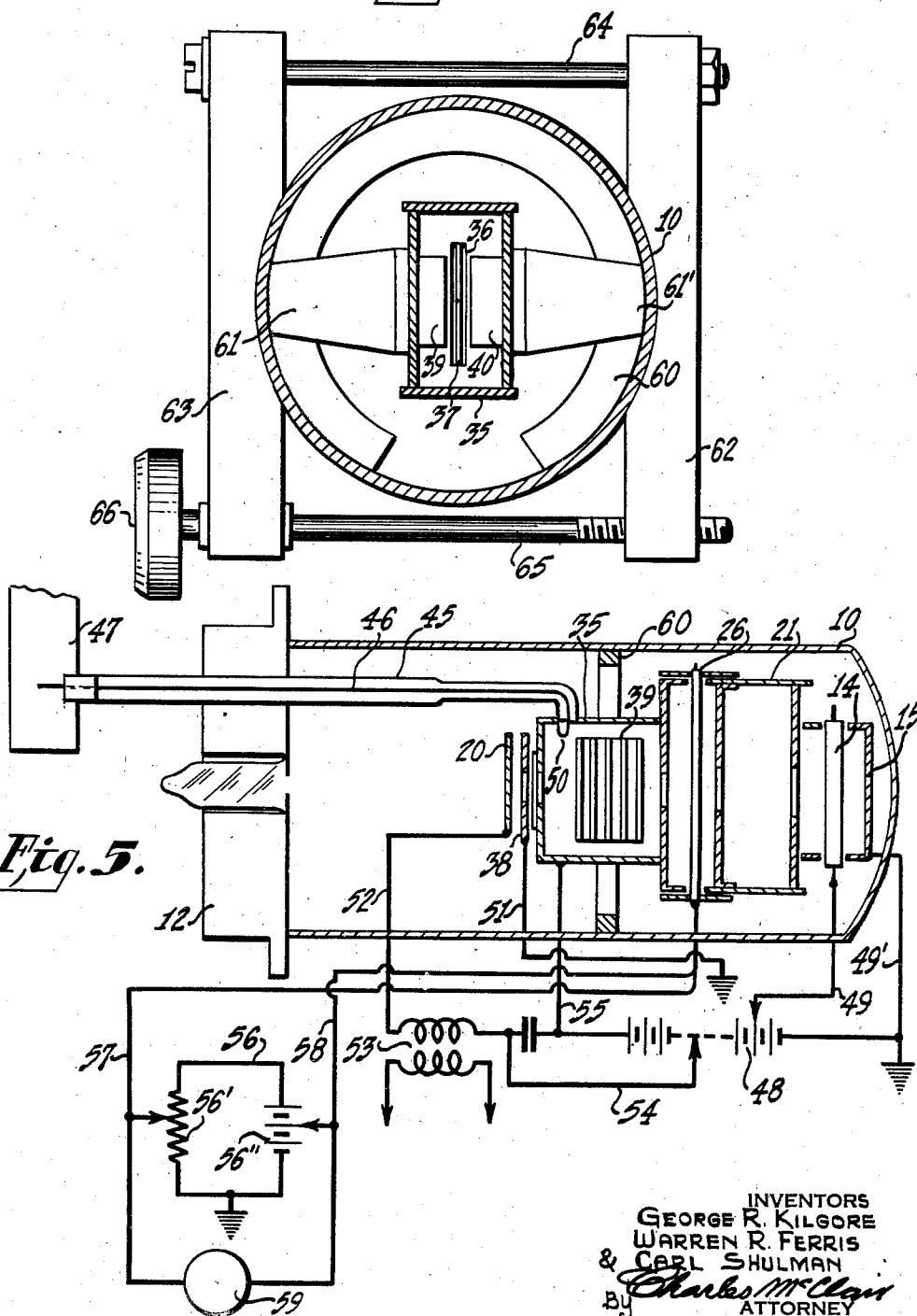


Fig. 5.

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2,407,163

ELECTRON DISCHARGE DEVICE

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Application July 28, 1943, Serial No. 496,420

8 Claims. (Cl. 315—6)

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Our invention relates to electron discharge devices utilizing periodic electron beam deflection and particularly useful at ultra high frequencies.

In electron discharge devices of the type under consideration, a beam of electrons is directed between a pair of deflecting electrodes toward an apertured electrode, behind which is usually placed a collector. Alternating high frequency voltages are applied to the deflecting electrodes to cause the electron beam to be periodically deflected across the aperture, to thus control the instantaneous flow of electron current to the collector, which may be used as an output electrode. In such types of tubes, the deflection sensitivity drops off as the frequency at which the tube is operated is increased due to electron transit time effects. Efforts have been made to increase the deflection sensitivity or the transconductance of the beam deflection tube at ultra high frequencies, but such efforts have not met with a great deal of success. Tubes of this kind are also subject to limitation when operated at ultra high frequencies since the input circuit tends to be of low resonant impedance, resulting in an excessive amount of power being required to drive the tube. This decreases the effective power gain of the tube when operated as an amplifier. Fundamental causes of low resonant impedance include, among other things, radiation and resistance losses due to high circulating current in electrodes and leads.

In a copending application, Serial No. 445,118 filed May 20, 1942, in the name of Carl I. Shulman and George Ross Kilgore and assigned to the same assignee as the present application, a form of electron discharge device is disclosed which overcomes the objections pointed out above. In the apparatus there disclosed the beam deflection portion of the mount structure is so constructed that it subjects the electron beam to multiple successive additive deflection, the beam being passed through a deflection system including a plurality of successive pairs of deflecting electrode elements mounted within a hollow waveguide or cavity resonator.

The principal object of the present invention is to still further improve an electron discharge device of the beam deflection type.

Another object of our invention is to provide a device of the kind described, which is of small size and completely shielded by a metal envelope.

A further object of our invention is to provide an electron discharge device of the multiple deflection type utilizing a tunable cavity resonator.

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A still further object of our invention is to provide such a device in which the cavity resonator can be tuned externally of the metal envelope of the device.

The novel features which we believe to be characteristic of our invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a longitudinal section of an electron discharge device made according to our invention, Figure 2 is a longitudinal section taken at 90° with respect to Figure 1, Figure 3 is a view of the beam forming system within the envelope as viewed in the direction of the arrow shown in Figure 1 and showing details of construction, Figure 4 is a transverse section taken along the line 4—4 of Figure 2, Figure 5 is a schematic longitudinal section of the device shown in Figures 1 and 2 with its associated circuit elements.

In accordance with our invention the electron discharge device employs a metallic envelope and header of conventional design within which the electrode system is mounted. Specifically and referring to Figures 1, 2 and 3, it includes the evacuated envelope 10 sealed by the usual header 11 and insulating base 12 provided with the usual pins 12' and support leads sealed through the header.

The amount assembly is positioned vertically within the envelope so that the beam of electrons is directed downwardly toward the base. Mounted at the upper end of the envelope is the cathode assembly comprising indirectly heated cathode 14 partially surrounded by the beam forming and shielding electrode 15, these two electrodes being supported between the oppositely disposed insulating spacers 16 and 17, preferably of mica. The cathode 14 is provided with a lead 18 coated with insulating material 19 as shown. Positioned at the other end of the mount assembly is collector 20 suitably supported from the header, for example, by means of support rod and bead construction 20' and provided with a lead 20'' through the header 11.

Positioned between the cathode assembly and the collector is the beam forming electrode assembly and deflection electrode assembly. This comprises a preferably cylindrical member 21 having three spaced partition elements 22, 23 and 24, which are provided with the aligned apertures 22', 23' and 24', the cathode assembly being supported at one end adjacent the partition 22. Positioned between the partitions 23 and 24 are

rod-like electrodes 26 and 27 between which the beam is directed and which control the direction of the beam on its further passage through the mount assembly. These beam directing electrodes are supported between the partition members by the bead and support wire assembly 28 and 29, mica shields 30 and 31 being provided at opposite ends of the assembly. Leads such as 32 may be provided for the beam forming electrode assembly for applying a potential thereto.

At the lower end of the beam forming assembly is a beam deflection electrode assembly comprising the box-like hollow resonator 35 having the aperture 36, axially of which is positioned the rod 37 for providing a double aperture, a suppressor electrode 38 being positioned between the end of the cavity resonator 35 and collector 20. The deflecting electrode elements include the block-like elements 39 and 40 provided with oppositely disposed teeth 39' and 40' which are spaced from center-to-center a distance equal to the distance travelled by an electron during a full period at the resonant frequency of the resonator 35 so that the deflected electrons will come under the influence of the deflecting electrodes at each period so that deflection is always in the same direction.

The interior of the resonator is coupled to a waveguide by means of the coaxial line comprising outer conductor 45 and inner conductor 46, the end of the inner conductor extending within the waveguide 47 and supported in insulated spaced relationship with the glass insulator members 48 and 49, the inner end of the inner conductor being provided with coupling loop 50 extending within the resonator. The resonator operates in such a mode that all teeth, for example 39', on one side of the resonator and forming deflecting electrode elements are at the same potential but 180° out of phase with the potential on the opposing deflecting electrode elements, for example 40'.

For tuning purposes we provide a ring-like member 60, shown in greater detail in Figure 4, closely engaging the interior of the envelope of the tube. This ring is maintained under compression so that its tendency is to move outwardly toward the inner surface of the shell 10. Connected between it and the sides of the cavity resonator 35 are the arms 61 and 61' which cause flexing of the sides of the resonator and hence a change in its resonant frequency upon compression of the ring 60. Compression is accomplished, deforming the outside of the tube, by means of the arrangement shown by which cross bars 62 and 63 engage opposite sides of the shell 10 adjacent to arms 61 and 61'. One end of the bars 62 and 63 are secured together by means of the rod 64, the other ends of the bars 62 and 63 may be brought closer together by means of screw 65 operated by means of the knob 66.

As shown in Figure 5, the cathode is maintained at a slightly positive potential with respect to the electrode shield 15 by means of conductors 49 and 49' connected to the voltage source 48 and the ground. The beam forming and deflecting electrode system is maintained at a high positive potential with respect to the cathode by means of the lead 55 connected to the high side of the voltage source 48. The suppressor 38 is connected to ground by means of conductor 51. The collector 20 may serve as an output electrode and is connected to the output transformer 53 by means of conductor 52 and maintained at a slightly lower potential than the beam forming

and beam deflecting electrode system by means of the conductor 54. To vary the relative potentials between the beam directing rod electrodes 26 and 27, we provide a potentiometer arrangement 56 comprising a resistor 56' and voltage source 56'', the voltage being fed to the deflection rods by leads 57 and 58. If desired a local oscillator voltage may be applied to the rods 26 and 27 by means of the oscillator 59.

In operation energy is fed into the cavity resonator 35 by being directed down the waveguide 47 and through the coaxial lines 46 and 45 to the loop 50 at the end of the coaxial line. This energizes the cavity resonator so that as the beam of electrons is directed through the beam forming electrode system and between the deflecting electrode elements it will be deflected across the double apertures 36 of the cavity resonator and collected by means of the output electrode 20 which feeds the energy to the output transformer 53. As pointed out above, the spacing between the centers of the deflecting electrode elements is equal to the distance travelled by an electron during a full period of the applied voltage to the cavity resonator, so that the electrons will be deflected in the same direction by each pair of deflecting elements between which the electron passes.

Thus in accordance with our invention, we provide an electron discharge device of the beam deflection type, particularly suited for use at ultra high frequencies, which is of small size and which is completely shielded and in which the cavity resonator may be tuned externally of the envelope of the tube. By using the conventional header construction, sealing can be taken care of in a simple manner and assembly and production facilitated.

While we have indicated the preferred embodiments of our invention of which we are now aware and have also indicated only one specific application for which our invention may be employed, it will be apparent that our invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of our invention as set forth in the appended claims.

What we claim as new is:

1. An electron discharge device including an envelope, a cathode within said envelope for supplying a beam of electrons, means within said envelope for receiving said electrons, and means positioned between said cathode and receiving means and through which the beam path lies, and including a cavity resonator within said envelope, tuning means for said resonator connecting the cavity resonator to the inner walls of the envelope and including a deformable ring contacting the inner walls of said envelope, and arms extending between said deformable ring and the walls of said resonator.

2. An electron discharge device including an envelope, a cathode within said envelope for supplying a beam of electrons, means within said envelope for receiving said electrons, and means positioned between said cathode and receiving means and through which the beam path lies and including a cavity resonator within said envelope, and means connecting the inner walls of the envelope to the cavity resonator including a split ring contacting the inner walls of said envelope, and arms extending between said split ring and the walls of said resonator, and

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adjusting means positioned externally of the envelope including a vise-like clamp for compressing the walls of said resonator adjacent the ends of said arms connected to said split ring for tuning said cavity resonator.

3. An electron discharge device including a metallic envelope, a cathode within said envelope for supplying a beam of electrons, means within said envelope for receiving said electrons, and means positioned between said cathode and receiving means through which the beam path lies for periodically deflecting the beam of electrons during operation of said electron discharge device, the deflecting means including a cavity resonator and arms contacting the inner walls of said envelope and connected to the cavity resonator, and adjustable means positioned externally of said envelope and contacting the outer walls of said envelope for tuning the cavity resonator through said arms by pressure on the outer walls of the envelope.

4. An electron discharge device including a metallic envelope, a cathode within said envelope for supplying a beam of electrons, means within said envelope for receiving said electrons, and means positioned between the cathode and receiving means and through which the beam path lies, and including a cavity resonator within said envelope, tuning means for said cavity resonator connecting the cavity resonator to the inner walls of the envelope and including a split ring contacting the inner walls of said envelope, and arms extending between the split ring and the walls of said resonator, and adjusting means for compressing the envelope for contracting the split ring.

5. An electron discharge device including a metallic envelope, a cathode within said envelope for supplying a beam of electrons, means within said envelope for receiving said electrons, deflecting means positioned between said cathode and receiving means and through which the beam path lies for periodically deflecting said beam of electrons during operation of said electron discharge device, the deflecting means including a cavity resonator within said envelope, the interior of said resonator being provided with a plurality of opposed successively positioned deflecting elements between which the beam path lies and tuning means for said resonator connecting the cavity resonator to the inner walls of the envelope and including a deformable ring contacting the inner walls of said envelope, and means connecting said deformable ring to walls of said resonator.

6. An electron discharge device including a metallic envelope, a cathode within said envelope for supplying a beam of electrons, means within said envelope for receiving said electrons, and deflecting means positioned between said cathode and receiving means and through which said beam path lies for periodically deflecting said beam of electrons during operation of said electron discharge device, said deflecting means including a cavity resonator within said envelope, said cavity resonator having a plurality of suc-

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cessively positioned opposed deflecting elements spaced along the walls thereof and between which the beam path lies, said elements being spaced along the beam path equal to the distance travelled by an electron during a period of applied alternating voltage to said resonator, means connecting the inner walls of the envelope to the cavity resonator for varying the position of the walls of said resonator with respect to each other for tuning said resonator, and adjusting means positioned externally of the tube envelope for compressing the walls of said envelope to tune said resonator.

7. An electron discharge device having an elongated metallic envelope, a header on said envelope closing said envelope and having a plurality of leads sealed therethrough, a cathode at one end of said envelope for supplying a beam of electrons; a collector within said envelope for receiving said electrons and a beam forming and deflecting electrode assembly positioned between said cathode and said collector and including a beam forming means comprising a plurality of successively positioned apertured electrodes through which the beam path lies and a cavity resonator within said envelope positioned between said collector and said beam forming assembly and including a plurality of oppositely disposed successively positioned deflecting elements positioned within the resonator, the beam path lying between said deflecting elements, said leads being connected to said cathode, collector and beam forming and deflecting electrode assembly, a coupling loop within said resonator and a coaxial transmission line connected to said loop and said resonator for exciting said resonator when an alternating voltage is fed into said coaxial transmission line, said coaxial transmission line extending through said header and sealed thereto.

8. An electron discharge device having an elongated metallic envelope, a header on said envelope for closing said envelope and having a plurality of leads sealed therethrough, a cathode at one end of said envelope for supplying a beam of electrons, a collector within said envelope for receiving said electrons, and a beam forming and deflecting electrode assembly positioned between said cathode and said collector and including a beam forming means comprising an apertured element through which the beam path lies, and a cavity resonator within said envelope positioned between said collector and said beam forming means, and including oppositely disposed deflecting elements positioned within the resonator, the beam path lying between said deflecting elements, said leads being connected to said cathode, collector and beam forming and deflecting electrode assembly, and a coaxial line coupling loop communicating with said resonator and extending through and sealed through said header.

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