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ELECTRON DISCHARGE DEVICE

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Fig. 1.

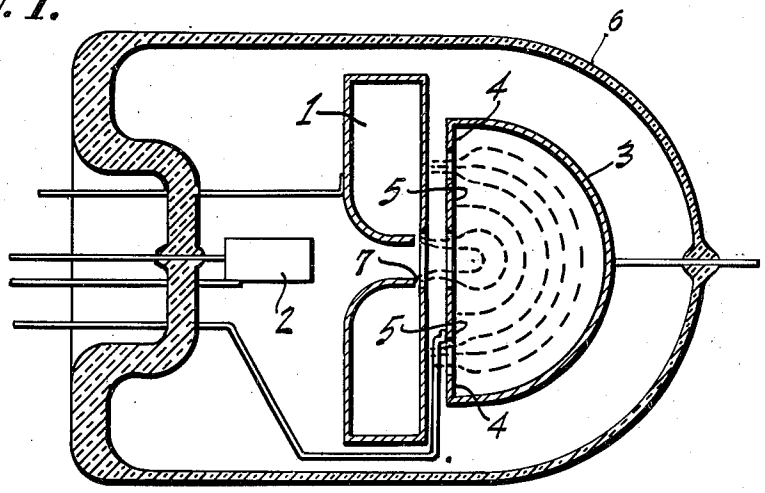
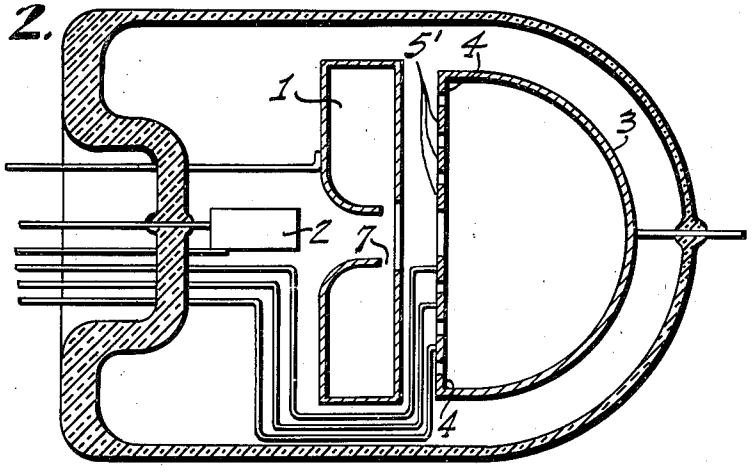


Fig. 2.



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ELECTRON DISCHARGE DEVICE

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This invention relates to electron discharge devices employing hollow resonators of the kind in which a reflecting electrode is provided which, if maintained at a suitable potential, causes electrons passing through the gap in the resonator to be reflected back towards the resonator.

It has been proposed to construct an electron discharge device of the above kind in which an electron beam is caused to pass through the gap in the resonator within which electric waves are set up and thereby to effect so-called velocity-modulation of the beam. After passing through the resonator the velocity-modulated beam is reflected back through the resonator, the beam passing through a sufficient distance to enable bunching of the electrons to occur so that the velocity-modulation becomes converted to so-called charge density modulation. The voltage applied to the resonator, and the distance between the resonator and the reflecting electrode and the voltage applied to the reflecting electrode can be so chosen that the reflected electron bunches arrive at the resonator in such a phase relation to the oscillations already occurring in the resonator that the device can be made to function as a generator of self-maintained oscillations.

In the case of an electron discharge device of the kind above referred to in which the electron stream passes through a gap formed by circular apertures in opposite surfaces of the resonator, the electrons pass through the gap into the retarding field produced by the reflecting electrode with varying velocities and in directions spread over a cone with an angle of about 30°. With known forms of devices of the kind referred to it is found that the efficiency is reduced due to the fact that only a small proportion of the electrons which enter the retarding field are returned through the resonator. I have found that the loss of efficiency is mainly due to the incorrect shape of the equi-potential surfaces facing the hollow resonator through which the electrons pass to be reflected and through which the electrons pass on their return to the resonator. The equi-potential surfaces facing the resonator should be of concave form and whilst devices have been proposed employing reflecting electrodes of concave form the efficiency is still of a low order. This is due to the fact that whilst the equi-potential surfaces are of concave form close to the reflecting electrode they rapidly flatten out towards the resonator where the equi-potential surfaces may even be convex facing the resonator if the shape of the wall of the resonator nearer the reflecting electrode is of re-entrant form. I have

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found that a substantial improvement in efficiency can be obtained by making the equi-potential surfaces between the resonator and the reflecting electrode more nearly concentric with one another.

According therefore to one feature of the present invention, there is provided an electron discharge device of the kind described embodying such a device wherein the reflecting electrode is so shaped that it is capable of setting up equi-potential surfaces of concave form with the concavities facing the hollow resonator and wherein means are provided capable of causing the majority of the equi-potential surfaces lying in the path of the electron stream to be substantially more nearly concentric than would otherwise be the case.

The equi-potential surfaces need only be more nearly concentric where they lie in the path of the electrons. For example, if the electrons spread over a cone of 30° as suggested above, the equi-potential surfaces need only be concentric within said cone since the form of the equi-potential surface outside the cone is immaterial.

In one form of the invention said means comprise a further electrode having a gap through which electrons pass towards the reflecting electrode, said further electrode being located adjacent to and extending across the end of the reflecting electrode adjacent to the resonator. This further electrode is maintained at a potential intermediate that of the reflecting electrode and the hollow resonator.

Preferably, said reflecting electrode is of hemispherical form in cross section, but other shapes of reflecting electrode may, if desired, be employed. For example, it is possible to set up equi-potential surfaces which are of concave form facing the hollow resonator by employing a reflecting electrode of cylindrical form. If desired, the said further electrode may be replaced by a plurality of electrodes or may be replaced by an electrode the resistance of which progressively varies as will be hereinafter referred to.

In order that the said invention may be clearly understood and readily carried into effect, it will now be more fully described with reference to the drawing in which Figure 1 is a diagrammatic transverse section of one embodiment of a discharge device according to my invention, and Figure 2 shows a modification of Figure 1.

The device has an evacuated envelope 6 containing a cathode 2, and the hollow resonator 1 which may be of any suitable shape, but it is shown in the example illustrated with a flat rear

surface. The resonator may be in the form of a toroid, electrons being passed through the gap 7 into a retarding and reflecting field generated by a reflecting electrode 3. The electron stream passing through the gap 7 may emanate from a cathode with any suitable accelerating or focusing electrodes, or alternatively, the electron stream which enters the gap 7 may be a velocity-modulated stream emanating from a further resonator. The electron beam is assumed to be of circular form in cross-section and in this case the reflecting electrode 3 is in the form of a hemisphere with its concavity facing the gap 7 and is disposed as close to the flat rear surface of the resonator 1 as is possible. The periphery of the reflecting electrode 3 is provided with an annular flange 4 and disposed in the same plane as the flange 4 is a further electrode 5, also in the form of an annulus, and having a central gap aligned with the gap 7.

In operation, the reflecting electrode 3 may be maintained at a potential negative to the cathode so that the electrons passing through the gap will be reflected and passed back through the gap 7, in a known manner. The reflecting electrode causes equi-potential surfaces to be set up which are of concave form facing the gap 7. However, these equi-potential surfaces would, in the absence of the electrode 5, rapidly flatten out towards the resonator giving rise to the loss of efficiency aforesaid. However, by maintaining the electrode 5 at a potential intermediate that of the electrode 3 and the resonator 1 the equi-potential surfaces are made more nearly concentric with one another. The equi-potential surfaces are shown by the dotted lines in the figure. The equi-potential surfaces nearer the electrode 3 are of substantially hemispherical form, whilst the equi-potential surfaces nearer the apertures 7 are somewhat distorted from a true hemisphere but are, nevertheless, substantially concentric with the surfaces nearer the electrode 3. As stated above, those portions of the equi-potential surfaces which are of importance in improving the efficiency, are those portions lying in the path of the electron stream. In the example shown, if the electron stream spreads from the gap 7 over a cone of an angle of 30° the equi-potential surfaces within such a cone will all be substantially more nearly concentric.

Whilst the arrangement shown improves the efficiency compared with known forms, a further improvement can be effected as shown in Figure 2 by providing a plurality of electrodes 5' similar to electrode 5 and arranged in the plane of the annular flange 4, and concentric with the axis of the electrode 3, the various electrodes being maintained at potentials which progressively increase from the outermost electrode, which will be at a slightly more positive potential than the electrode 3, to the innermost electrode which will be at a potential near that of the resonator 1.

The electrode 5 may even be in the form of an electrode having a progressively varying resistance in radial directions whereby a potential gradient is set up so as to afford, in effect, an infinite number of electrodes with progressively varying potentials which increases towards the gap in the electrode 5.

It is not necessary for the further electrode or electrodes to lie in a plane as stated above, since the boundary of the electrode 3 may be completed by any suitable arbitrary surface. For example, the further electrode or electrodes may be in the form of frustrums or cones.

The invention may be applied to electron discharge devices, the hollow resonators of which are of any suitable form and can with advantage be applied to resonators of the form in which the gap in the resonator is of annular form, that is to say, the resonator is in the form of a toroid generated by rotating a substantially dumb-bell shaped figure or a figure similar to the cross-section of the resonator 1 in the drawing about an axis displaced from the axis of the gap 7. In such cases the reflecting electrode 3 would have the cross-section shown in the drawing, but would be of toroidal form and the further electrode or electrodes would be shaped accordingly. Furthermore, the invention may be applied to cases in which the electron stream is not of circular form in section, but is of elongated shape in cross-section. With such a form of electron stream an elongated gap will be provided in the resonator and the resonator will no longer then be of toroidal form, but will comprise an elongated figure having the cross-section shown in the figure. The reflecting electrode 3 in such a case and the electrode 5 will have the cross-section shown, but the electrode 3 will be a semi-cylinder and the electrode 5 a pair of strips.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my 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 my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device including a cavity resonator having a passageway extending therethrough, and a gap surrounding said passageway, means adjacent said resonator for directing a stream of electrons through said passageway, and an electrode on the opposite side of said resonator and of concave form with the concavity facing the hollow resonator for providing reflecting equi-potential surfaces of concave form with the resonator, and an electrode positioned adjacent said resonator and having an aperture registering with the passageway through said resonator, said last electrode extending across the end of the reflecting electrode, and being adapted to be maintained at a potential intermediate that of the reflecting electrode and the resonator.

2. An electron discharge device having a resonator means adapted to be excited by an electron stream and including a conducting element having an aperture, cathode means adjacent said resonator means for directing a stream of electrons through said aperture, and an electrode on the opposite side of said resonator means and of concave form with a concavity facing said resonator means for providing reflecting equi-potential surfaces of concave form with said resonator means, and an electrode positioned adjacent said resonator means, and having an aperture registering with the aperture in said resonator means, said last electrode extending across the end of the reflecting electrode, said last electrode being adapted to be maintained at a potential intermediate that of the reflecting electrode and said means.

3. An electron discharge device including a cavity resonator having a passageway extending therethrough and a gap surrounding said pas-

sageway, one side of said resonator being plane, means adjacent said resonator for providing a stream of electrons through the passageway of said resonator, an electrode on the opposite side of the resonator from said electron providing means and being of concave shape, the concave side facing said resonator and having a lip lying in a plane parallel to the plane surface of said resonator and adjacent thereto, and another electrode having an aperture registering with the passageway through said resonator and lying in the plane of said lip but out of contact therewith, said last electrode and said concave electrode designed to provide reflecting equi-potential surfaces of concave form.

4. An electron discharge device including a cavity resonator having a passageway extending therethrough and a gap surrounding said passageway, one side of said resonator being plane, means adjacent said resonator for providing a stream of electrons through the passageway of said resonator, an electrode on the opposite side

of the resonator from said electron providing means and being of concave shape, the concave side facing said resonator and having a lip lying in a plane parallel to the plane surface of said resonator and adjacent thereto, and concentric electrodes one having an aperture registering with the passageway through said resonator and lying in the plane of said lip but out of contact therewith, said last electrodes and said concave electrode designed to provide reflecting equi-potential surfaces of concave form.

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